POWER

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Party Politics in Government Engineering

MUCH has been said and written recently about the part that the engineer should play in public affairs.

He is urged to give of his time and talent to civic interest that municipal, state and national administrations may profit by his faculty of unemotional analysis and his special knowledge of the engineering which has come to be so large a factor in communal existence.

A movement has been started toward consolidating the civic engineering activities of the Federal Government into a Department of Public Works.

The hoped-for recognition of the importance of the engineer in governmental functions got a setback the other day, when Arthur P. Davis was asked by Secretary Work of the Department of the Interior to hand in his resignation as Director of the Reclamation Service.

And in generous recognition of his forty years of devoted expert professional work for his country, his pay was allowed to go on for two weeks after his dismissal.

Arthur Davis did not need two weeks to find another job. Industry has been bidding more money for him for a long time than the government has been paying him. But his heart was in his work. He has made the Reclamation Service what it is, and he wanted to finish the job or finish his years of competency on it, even at a sacrifice.

Why was he put out?

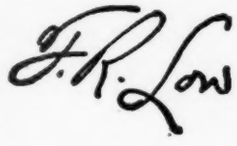
The reason given by the Secretary is that he wants to put a business man in charge. So he appoints a man who was a successful grocer, not so successful a banker, but a clever politician.

We thought we had that sort of thing fixed, didn't we? The civil service law, to say nothing of an overwhelming public sentiment against the uprooting of faithful government servants and the destruction of efficient organization for the purposes of partisan politics, ought to prevent it.

But no law is impregnable to those in power. All that Secretary Work had to do was to abolish the office of "Director" and appoint the new man, whose name is also Davis, as "Commissioner."

And so we have the spectacle of one highly professional man—not a business man himself, by the way—a past president of the American Medical Society, dismissing another highly professional man, a past president of the American Society of Civil Engineers, to make room for a business man as director—pardon me, "Commissioner"—of a service that is largely one of civil engineering.

If this kind of a thing is allowed to stand unchallenged, all the talk of putting the engineer to the front in the reconditioning of the country is as sounding brass and a tinkling cymbal. And unless Secretary Work and those who speak for him have a better excuse for it than they have yet shown, they may find that public revulsion against party politics in engineering is less easy to deal with than an evasion of the civil service law.



Some Engineering Features of the Weymouth Station

BY I. E. MOULTROP† AND JOSEPH POPE‡

The new power station of the Edison Electric Illuminating Company of Boston, now under construction at Weymouth, will have an ultimate capacity of about 300,000 kw. The present construction covers the installation of two 32,000-kw. generating units with three 19,740-sq.ft. boilers, operating at 375 lb. pressure and 700 deg. In addition, a single boiler to carry steam at pressures up to 1,200 lb. is to be installed. This boiler will have about the same heating surface as the normal pressure boilers. The steam generated by it will pass through a pressure-reducing turbine developing about 2,000 kw., and will be exhausted at 375 lb. pressure. After being reheated to the original temperature of 700 deg., the steam will be piped to the main header and used in the large turbines. Three will be required to furnish sufficient steam to operate one of the 32,000-kw. units.

THE Edison Electric Illuminating Company of Boston has found its existing power stations and sites developed to their economical limits. Faced with a rapidly growing demand for service and with a broad vision into the future, it is constructing, on an entirely new site, the initial development of a station expected to have an ultimate capacity of approximately 300,000 kilowatts.

The selected site on the Fore River in Weymouth contains about 63 acres. It is on deep water, readily accessible by large ocean-going coal carriers, and has all other advantages necessary to give entire freedom in the design of a large modern station. Fig. 1 shows the general cross-section of the station.

The initial main generating equipment will consist of two 32,000-kw. turbines each driving a main 30,000-kw. generator and a 2,000-kw. auxiliary generator direct-connected to the shaft of the main generator. These units will be supplied with steam at a nominal pressure of 375-lb. and a total temperature of 700 deg. F. There will also be one 2,500-kw. high back-pressure turbo-generator taking steam up to 1,200 lb. pressure and exhausting into the 375-lb. system. All station auxiliaries are to be driven by alternating-current motors.

The boiler installation will include three boilers each containing 19,743 sq.ft. of heating surface, with additional superheater and economizer surface, designed for 375-lb. working pressure. There will also be one boiler, of approximately the same heating surface, which will be designed to operate at a maximum of 1,200 lb. It will likewise be provided with a superheater and an economizer, and also a steam reheater to restore the temperature of the exhaust steam from the high back pressure turbine to 700 deg. before it passes into the 375-lb. system. All boilers will be fired with underfeed stokers.

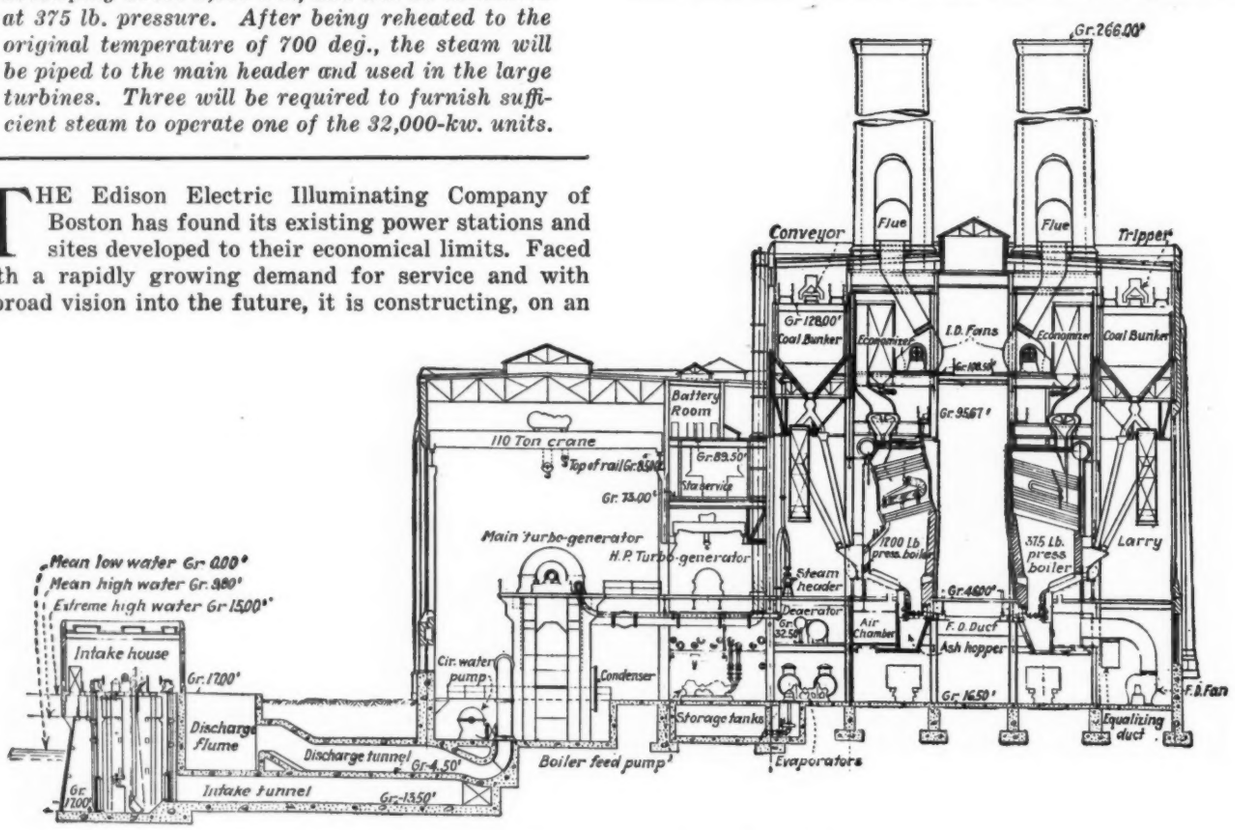


FIG. 1—CROSS-SECTION THROUGH WEYMOUTH STATION

The coal-handling equipment will consist of two electric unloading towers, a traveling bridge spanning the storage pile, and a system of belt conveyors for trans-

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†Edison Electric Ill. Co., Boston. ‡Stone & Webster, Inc.

porting the coal to or from the main storage or directly from the unloading towers to the station bunkers. The conveyor for delivering the coal to the station will be about 700 ft. in length. The traveling bridge is to carry a man trolley with bucket for reclaiming from the storage pile. A Bradford breaker will be used for crushing the coal on its way to the station.

Current will be generated at 14,000 volts, three phase, 60 cycles. It will be distributed from the station through underground circuits partly at generator voltage and partly at 25,000 volts through an adjacent outdoor transformer substation. Future transmission by overhead lines at 115,000 volts will also be provided for. The bus and switching arrangement is described later in this paper.

Selection of Steam Conditions

The selection of the steam temperature is almost entirely a problem of materials, as the beneficial effect of superheat, although largely indirect, continues in worthwhile proportion up to the maximum temperature which our engineering materials will properly withstand. In some isolated instances European engineers have employed temperatures as high as 750 deg. to 800 deg. F. and in America temperatures as high as 725 deg. F. have been chosen by some designers. In considering this matter for the Weymouth Station it

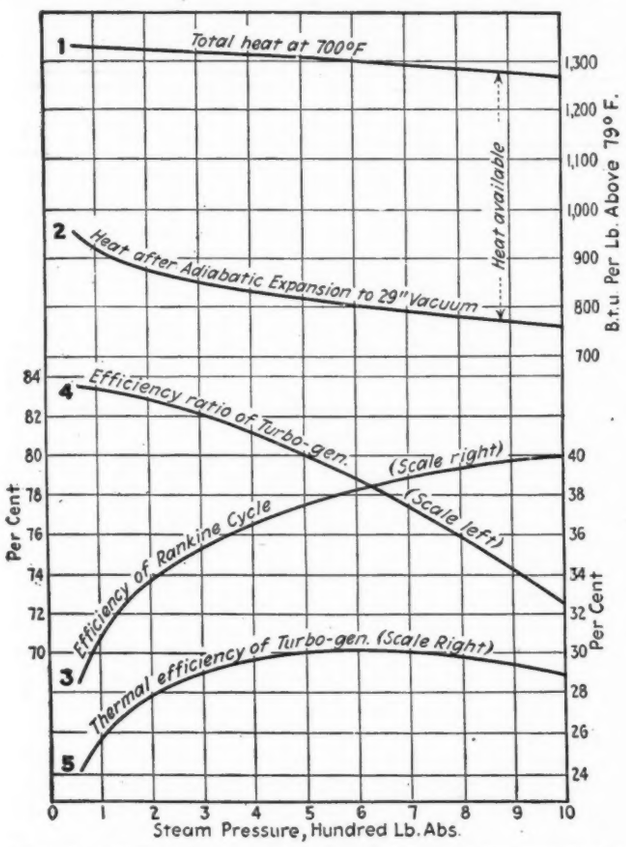


FIG. 2—EFFECT OF STEAM TEMPERATURE ON TURBINE EFFICIENCY

seemed best to place the nominal limit at 700 deg. F. It, however, appeared entirely practicable to employ this limiting temperature regardless of the pressure adopted.

Decision as to the most advantageous steam pressure could not be reached without a much more involved study, especially in view of the general lack of experience with the higher pressures and a decided variation in prophecy as to the net advantage to be derived through their use.

The development of one part of the study to deter-

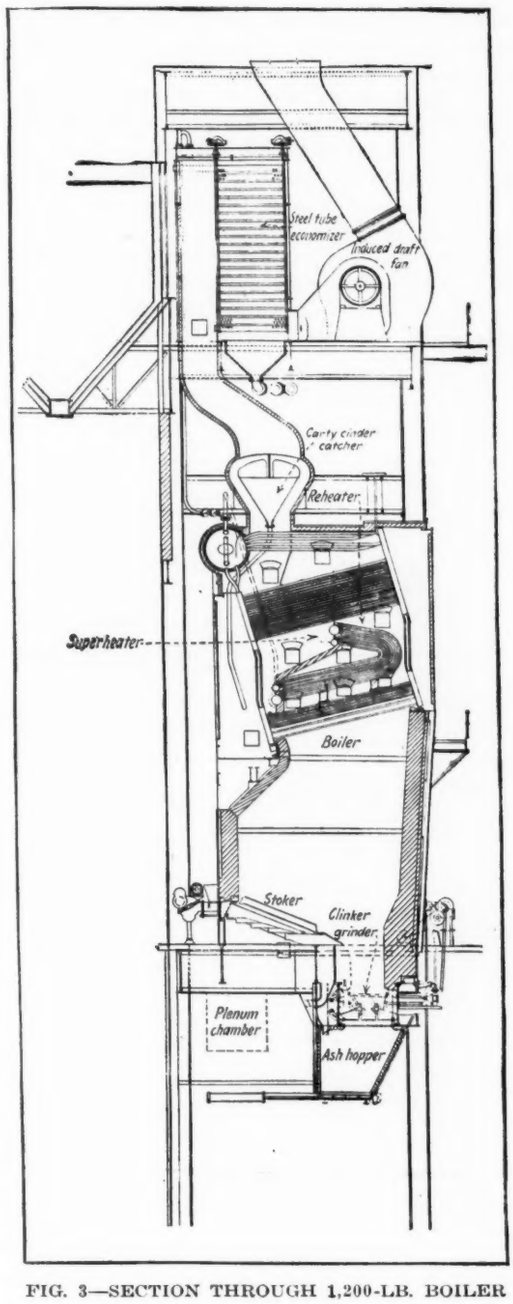


FIG. 3—SECTION THROUGH 1,200-LB. BOILER

mine the effect of the higher pressure upon improved economy is illustrated by the curves in Fig. 2. All these curves have absolute steam pressure as their abscissas.

Curve No. 1 shows the total heat in one pound of steam at a uniform temperature of 700 deg. F. above 79 deg. F., which is the temperature corresponding to one inch absolute pressure. It will be noticed that the total heat shows a decrease with increasing pressure.

Curve No. 2 shows the heat remaining in the steam after perfect adiabatic expansion from the stated initial conditions to a pressure of 1 in. absolute. The vertical

distance between this curve and curve No. 1 accordingly represents the B.t.u. per pound of steam theoretically available for doing work.

Curve No. 3 is a plotting of the available heat as a percentage of the total initial heat shown by curve No. 1 and represents the efficiency of the Rankine cycle at varying pressure. Its upwardly convex curvature indicates how the rate of increase in theoretical efficiency diminishes with increasing pressure.

Curve No. 4 shows the best efficiency at present to be expected of turbo-generators in converting the available heat, as shown by Curve No. 3, into useful electrical energy. In determining this curve the unit is credited with all heat recovered in the condensate by bleeding at two stages.

Curve No. 5 is the product of Curves No. 3 and No. 4 and indicates, for the different pressures, the percentage of the total initial heat in the steam which would be actually converted into electrical energy or returned to reached. This lowered efficiency is particularly marked where the maximum permissible total temperature causes the higher pressures to be accompanied by diminished superheat, thus advancing the dew point to an earlier stage. The recognized method of meeting this difficulty and thus permitting the superior possibilities of higher steam pressures to be realized, is to interrupt the expansion of the steam at some intermediate pressure and restore its temperature by reheating before the expansion is continued. This may be accomplished either by employing two independent turbines, one exhausting to the other through the reheater, or by returning the reheated steam to the lower stages of the same machine from which it was extracted. The design of the Weymouth Station makes provision for employing the first of these two methods using a maximum pressure of 1,200 lb.

In order that the reheater may be required to add superheat only to the steam, it is necessary that the

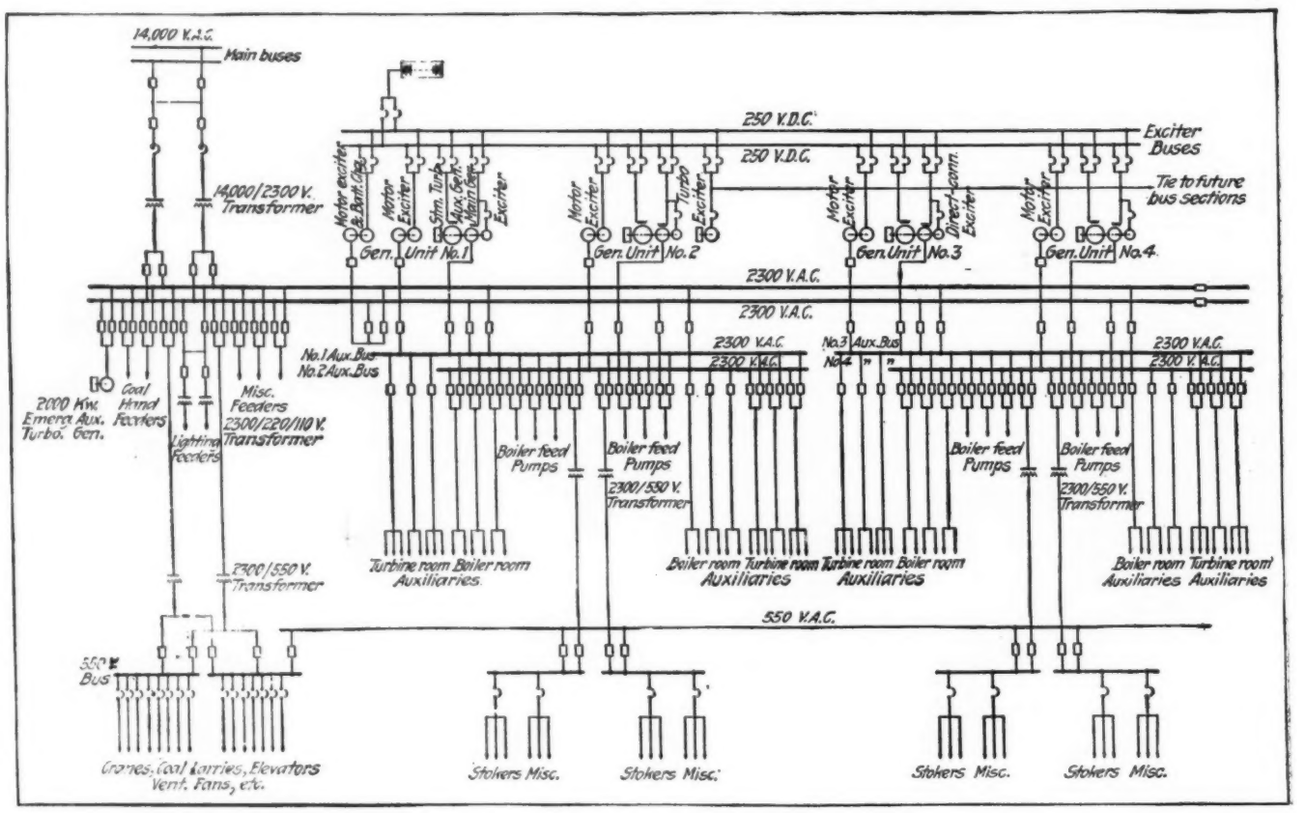


FIG. 4—AUXILIARY SWITCHING CONNECTIONS

the boiler in the condensate. It will be noted that this curve takes the shape of a dome with its highest point corresponding to a steam pressure of about 600 lb. absolute.

If steam turbines could be constructed which would be equally efficient in transforming the available heat energy into useful work under all of initial steam pressure conditions, Curve No. 3 would indicate that the over-all thermal efficiency would increase with the pressure throughout the entire range considered. The most important factors which act to decrease the turbine efficiency at higher steam pressure are the increased gland and interstage leakage loses and, more particularly, the increased steam friction occasioned by the entrained water after the dew point has been exhaust from the high-pressure turbine be dry. The amount of energy that may be extracted from a given weight of steam between an initial condition of about 1,000 lb. at 700 deg. and the dry saturated condition is only a fraction of that which can be utilized by its further expansion to vacuum after reheating. This condition permits the use of large standard design turbine units for the second expansion stage of the cycle. Thermodynamically, it makes little difference in the cycle efficiency at what pressure the steam is reheated, or, indeed, if it is reheated at all. In practical operation, there is a certain pressure at reheat which gives the best combined efficiency of the two turbines working in series, but the efficiency at this pressure does not appear to be a great deal higher than at other pressures.

rather widely different from it. Of greater importance are the mechanical problems connected with rehandling the steam, and the higher the pressure, within limits, the easier these become. For the particular situation under discussion it was desirable to have the lower-pressure portion of the plant able to function as a complete and highly economical station, so that the same considerations which control the selection of an initial pressure for the single expansion cycle were allowed to govern the choice of a reheat pressure in this case. Although it appears from Curve 5 of Fig. 2, that about 600 lb. is the most efficient pressure for a single expansion unit, cost influences makes a somewhat lower pressure more economical to use. For Weymouth Station the pressure selected is 375 lb.

High-Pressure Installation

The high-pressure boilers will normally deliver steam at approximately 1,000 lb. pressure and 700 deg. total temperature, corresponding to about 153 deg. of superheat. The entire steam output of each boiler, which under the usual operating conditions will be about 110,000 lb. per hour, will pass through a simple three-stage turbo-generator where it will be expanded down to a pressure of 375 lb. The steam will then be reheated to 700 deg. in a reheater installed in the same boiler setting, and finally be discharged into the 350-lb. header serving the main turbines. It may be noted from the quantity of steam passing through each of the high-pressure turbines that three such boiler-turbine units will be required to supply one of the main 32,000-kw. turbines at the higher loads. Operating under the conditions outlined, each of the high-pressure turbines will generate about 2,000 kw. Thus, a total of 6,000 kw. will be generated in reducing the pressure of the steam required by one of the main units.

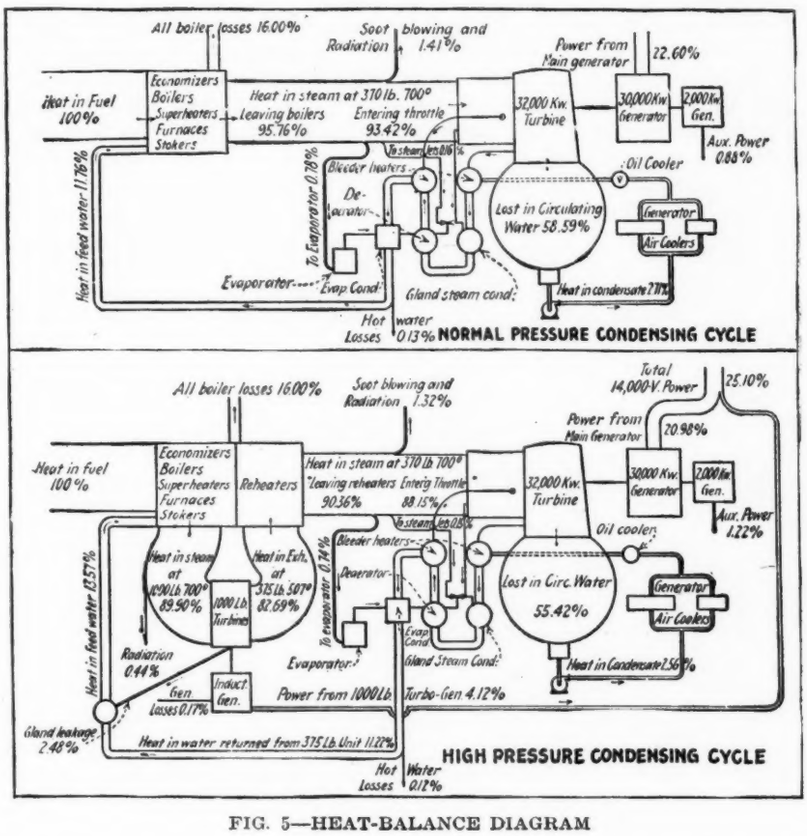


FIG. 5—HEAT-BALANCE DIAGRAM

The high-pressure boilers will have tubes 2 in. outside diameter and 15 ft. long. The tubes will be arranged in two banks with sufficient space between for the superheater and reheater. The drum will be a hollow steel forging 48 in. inside diameter with walls 4 in. thick. In order to maintain suitable drum strength, the tubes and nipples, which commonly enter the drum in lines parallel with its axis, are turned in pairs through an angle of 90 deg. so that the two enter the drum on a common circumference. Fig. 3 shows a cross-section of this boiler.

Boiler Plant and Feed-Water Heating

The normal pressure boilers, which are to deliver steam at 375 lb. and a final temperature of 700 deg. will be of the cross-drum design, 48 tubes wide and 17 tubes high, with the superheaters between the tube banks. The exit gases will be further cooled by straight steel tube economizers which, with the induced-draft fans, will be located above the boilers. The furnace arrangement provides for firing from the low end of the boilers. The stokers are to be of the underfeed type, with clinker grinders, there being 16 retorts per boiler. The boilers will be set with the bottom of the uptake headers 25 ft. above the firing floor. They will be arranged in parallel rows with the uptake ends facing a common center aisle from which all firing operations will be controlled. The stokers, which will thus be in the side aisles, will be supplied with coal from overhead longitudinal bunkers.

Makeup water is to be provided by evaporators and the entire supply will be deaerated to guard against corrosion.

Economizers with a heating surface equivalent to about 55 per cent of the boiler surface were chosen. This selection was preceded by a study of the following influential factors:

1. The temperature at which the feed water should leave the bleeder heaters and enter the economizers.

2. The most advantageous division of the total heating surface between the boiler and the economizer.

The capacity of the feed water to absorb heat is theoretically limited by the range between two fixed temperatures—that of the condensate and that of the saturated steam in the boiler. The practicable range of heating is, of course, somewhat narrower. The heat consumption of the main turbine, when credited with all heat returned to the system, is unquestionably the lowest when all the heating is done by extracted steam. On the other hand, the efficiency of the boiler plant is highest when the heating is all done in the economizer. The best over-all plant efficiency must therefore lie in some compromise between these opposing considerations. The calculations made for the Weymouth Station indicated that the most advantageous temperature to change the method of heating was between 210 deg. and 220 deg. F. Practically considered, this is a most desirable temperature also, for it avoids the use of super-

heated steam in the extraction heaters, diminishes the possibility of external corrosion of economizers and permits adequate deaeration of the feed water.

Considering the boiler and economizer in common, it is evident that for heating the water through a given total temperature range, and with a given outlet gas temperature, there will be less total heating surface required as the proportion arranged as counterflow economizer surface is increased. The relative cost of the two kinds of surface, however, exerts an opposing influence and necessitates a compromise. As to the boiler, its width is largely determined by the number of stoker retorts required, so its heating surface varies with its height. For the Weymouth Station the various considerations indicated that a boiler 17 tubes high and with 55 per cent additional economizer surface would provide the most satisfactory proportion, and that the resulting economy would justify the installation of this total amount of surface.

Decision to fire the boilers with stokers was reached only after a very careful study of the relative merits of using pulverized coal. The conditions surrounding this problem for the Weymouth Station were such that the probable savings in fuel through the use of powdered coal represented a relatively low percentage of the total fuel cost. This estimated saving was further reduced by the additional carrying charges to a margin which was too narrow to call clearly for the use of the powdered-coal system. It was accordingly decided to adhere to the present practice of the Edison company and employ stokers, at least for the initial boiler installation.

Auxiliary Drive

All the normally operating station auxiliaries are to be electrically driven, using alternating-current motors throughout. Motors of 25 hp. and less will, in general, be served at 550 volts, and those of greater capacity at 2,300 volts. Any necessary speed regulation is to be obtained through the use of brush shifting and slip-ring motors.

Power for all auxiliaries upon which the continuity of operation of the main units depends, will be supplied from auxiliary generators driven by the main turbines through direct connection to the shafts of the main generators. These auxiliary alternators will have a rating of 2,500 kva. and will generate at 2,300 volts, three phase. They will be mechanically in phase with the main generators, so that although they will normally operate independently, they may be connected to the main bus through suitable transformers when desired.

Each generator will be excited by a 175-kw. motor-generator set, consisting of a 2,300-volt induction motor and a 250-volt direct-current generator. This set will be operated from the direct-connected auxiliary generator. A spare motor-generator exciter and also a spare steam-driven exciter are to be installed for emergency excitation and for battery charging. A storage battery will float on the exciter bus. The 2,300-volt auxiliary generators will have direct-connected exciters, but in an emergency may be excited from the 250-volt buses.

The auxiliary generators, being driven by the main turbines, will produce electrical energy with the highest obtainable economy, practically equal to that of the main units themselves. It is therefore expected that the use of this system will permit the attainment of higher plant efficiency with greater security, than would be possible with any other method.

The complete avoidance of auxiliary exhaust steam permits the preliminary heating of the feed water to be accomplished entirely by multi-stage bleeding of the main turbine. It is well recognized that this method of heating results in greater efficiency than by the use of exhaust steam from individual auxiliary turbines, "house turbines," or any combination of them. In most other possible arrangements for heating the feed water entirely by bleeding the main units, the supply of auxiliary power must be taken from the bus and thus be subject to the effects of external electrical disturbances.

A wiring diagram of the system for driving the station auxiliaries is given in Fig. 4. The auxiliary generators will be controlled from the main switchboard, and the operator there will be responsible for keeping the 2,300-volt buses constantly energized.

Feed-water heating is to be accomplished both by steam extraction from the main turbines and by the use of economizers. To obtain the maximum of benefit from the steam extraction method of heating, motor-driven auxiliaries only are to be used, supplied with power from a most efficient direct-connected auxiliary alternator. The auxiliary apparatus itself has been selected with a view to obtain the highest efficiency in both the driving and driven members.

Fig. 5 shows, in the upper diagram, an analysis of the performance which could theoretically be realized in the operation of the normal pressure (375 lb.) portion of the station of the design as described. The lower diagram shows a similar analysis for such a station operating exclusively on the reheat cycle, with the entire steam supply generated at 1,000 lb. Both diagrams are based upon ideal operating conditions; that is, a constant station load of such amount and character as would permit the main units to operate at their point of best efficiency and at 100 per cent load factor. The estimated efficiency of each individual piece of equipment is that guaranteed by the manufacturer.

From these diagrams it will be observed that the normal-pressure straight condensing plant will transform 22.6 per cent of the heat in the fuel into electric energy, which is equivalent to 15,000 B.t.u. per kw.-hr. net generated, or approximately 1.05 lb. of coal of a heat value of 14,400 B.t.u. per lb.—while the corresponding figures for the high-pressure reheat plant are 25.1 per cent, 13,600 B.t.u. per kw.-hr. and approximately 0.945 lb. of coal.

Errata—Chimney Sizes

In the June 12 issue, page 936, the charts above and below should be interchanged. Captions at the bottom should read Figs. 7 and 8 instead of Figs. 6 and 7. The scale reading in terms of rated boiler-heating surface, square feet, should have read, "rated boiler-heating surface, thousands of square feet." Numeral 700 should be at the top line, instead of next to the top. As indicated in the caption at the bottom, this scale is to be used direct when boiler is to be operated at normal rating. At other ratings multiply the heating surface by the factor of rating and apply the result to the vertical scale. Thus, at normal rating, a stack diameter for 9,000 sq.ft., as in the example, requires an approximate diameter of 5.85 ft.; for the same figure at 200 per cent rating we should use 18,000 sq.ft. and obtain a diameter of about 7.8 ft.

Interpretation of Surface-Condenser Readings

By B. C. SPRAGUE
Efficiency Department, West Penn Power Company

The large number of variable factors affecting the heat transfer in surface condensers makes the determination of the condition of the tube surfaces from condenser readings very difficult. This article is designed to give those who have not made a special study of condensers an idea of the readings obtainable and their significance.

A FEW of the most important factors affecting the heat transfer are: The weight of steam condensed per unit of time; the inlet circulating-water temperature; the amount of air leakage; the volume of gases removed by the air pump or ejectors; the volume and velocity of the circulating water and the amount of deposited solids on the tube surfaces.

In condenser work the expression for heat-transferring capacity or efficiency is called the coefficient of heat transfer. This is the B.t.u. transferred per hour per square foot of tube surface, per degree Fahrenheit temperature difference between the steam and cooling water. The conductivity of the condenser-tube metal is very high, and the coefficient of heat transfer across the tubes alone would be over 20,000 B.t.u. Heat-transfer coefficients below 500 B.t.u., as obtained in condenser practice, are due to the high resistance of the film between the tube and water on one side and the steam on the other. In tests coefficients of heat transfer exceeding 1,000 B.t.u. have been obtained from air-free steam to water flowing at normal velocities through clean condenser tubes.

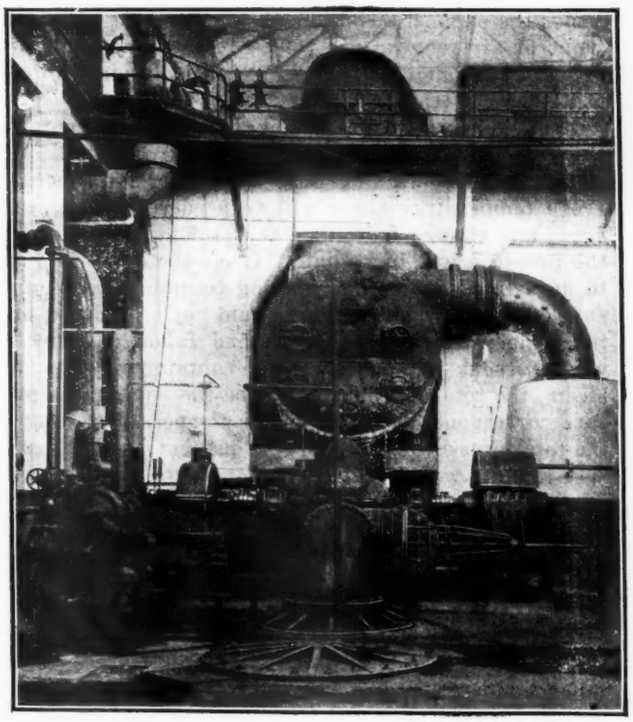
This coefficient of heat transfer is affected by a number of factors. Each has some direct bearing on one of the three resistances, which are: That due to the film between the water and tube; that due to the tube itself, including the attached scale and slime; and the resistance between the tube and steam.

One-Hundredth Inch of Scale Increases Resistance to Heat Flow Ten Times

When considering theoretically the transfer of heat between a flowing fluid and a tube, it is usually assumed that there is an infinitely thin film of the fluid entangled among the molecules and having the same temperature and relative velocity as the metal. It is further assumed that infinitely small particles or molecules of the fluid move continually into and out of this stationary film.

These particles, upon entering this film, are supposed to acquire and leave at the temperature of the film. As each particle, upon entering and leaving the film, undergoes not only a change in temperature, but also a change in kinetic energy, it is to be expected that there is a close relation between the rate of heat transfer and the resistance to flow of the fluid. Starting from the well-known law that the resistance to flow of liquids is proportioned to the density times the square of the velocity, it can be shown by making the foregoing assumptions that the rate of heat transfer by convection is directly proportional to the velocity and density. Many experiments made with water and gases have shown these theoretical deductions to be correct.

The resistance to heat transfer between the water and tubes is affected only by the velocity and viscosity of the circulating water. The resistance to heat flow offered by the tube metal itself is easy to determine, the flow of heat being simply by conduction. This resistance is but a small part of the total. If, however, we consider as part of the tube any solids adhering to its surface, its resistance may become relatively large. A coating of scale about one-hundredth of an inch thick will increase its resistance over ten times.



SURFACE CONDENSER SERVES LARGE TURBINE

Air Film on Tubes Resists Heat Transfer

The resistance to heat flow from tubes to air-free steam has been determined by several investigators. This resistance becomes large only when in commercial condensers a considerable quantity of air is present and is carried to the tube surface by the movement of the steam to the tube during the process of condensation. Contrary to expectation it has been shown by theoretical considerations and in actual tests that the conduction of heat through gases is independent of the density of the gas, the condition at the tube surface when no air is present being very similar to those that govern the conduction of heat in gases.

It is to be expected, and tests have demonstrated, that the rate of condensation is independent of the steam density if no air is present and the tube temperature is maintained constant. Air carried into the condenser by the incoming steam finds its way to the tube surfaces, there to remain unless washed away by the flow of steam to the tubes deeper in the tube bank, until removed by the slow process of natural diffusion. It can be seen that to keep these tubes free of this air film, they must all be in the direct path of the steam flow from the outside channels to the point where the non-condensable gases are removed. This is accomplished in some condensers by placing the air-pipe opening in the center of the circular tube bank through which the steam flows radially from all sides. Condensers that are poorly designed in this respect are still being sold. In these condensers only the tubes directly under the exhaust-steam opening and in the path to the point of air removal are fully effective, the stagnating of the air around the tubes in each end being so great that the heat transfer is very low.

It is generally known that for every temperature there is a corresponding water pressure; that is, in a closed vessel containing only water and its vapor, for every temperature there will be a corresponding pressure; any change in volume that would tend to reduce the pressure will immediately cause some of the water to flash into steam, thus tending to maintain the pressure constant. The pressure could not be reduced until the temperature of the water had fallen. If any air were present in such a vessel containing water and steam, the total pressure would be the sum of the pressure corresponding to the water temperature (that is, the total pressure if no air were present) and the pressure this air would exert if it alone were present in the vessel.

In such a closed container the air pressure is obtained by subtracting the pressure corresponding to the vapor temperature from the total pressure within. Since the density of this air is directly proportional to the pressure, the amount of air in a container holding both air and vapor can be determined if the total pressure and vapor temperature are known.

Weight of Air per Cubic Foot of Mixture in Condenser

With a total condenser absolute pressure of one inch of mercury each pound of entering steam has a volume of over 600 cu.ft. A 20,000-kw. turbine would thus exhaust over 2,000,000 cu.ft. of steam per minute. Since 10 cu.ft. per min. of air leakage would be considered as large for a turbine of this size, it can be seen that this air density in pounds of air per cubic foot of mixture as it enters the tubes, is inconceivably small.

When all but one-tenth of the steam that originally entered the condenser is condensed, the air pressure and density will be ten times as great as it was when the steam struck the first tubes. This is because the same amount of air is crowded into one-tenth of the volume. But even here the air pressure is still inconceivably small, and it is not until over 99 per cent of the steam is condensed that air pressure becomes appreciable. As the air pressure increases, the vapor pressure, and hence its temperature, decreases. The vapor pressure decreases even more than an amount equal to the increase in air pressure, owing to the drop in total pressure necessary to cause the steam flow across the tubes.

With a constant volumetric rate of removal of air-vapor mixture the conditions at the air-pipe entrance are governed by the air leakage and the pressure drop due to friction. Owing to the high air density, the lowered temperature and the low velocity of flow, the rate of heat transfer around the tubes near the air pipe is very low.

Measurements of the rise in temperature of circulating water in multiple-pass condensers show that there are two fairly well-defined zones in a surface condenser—one in which the air pressure is practically zero and the heat transfer rate is high, and one where the air pressure is approaching the value at which it will enter the air-removal pipe.

When air leakage is large, this later zone, although condensing a very small fraction of the steam, will probably comprise a large portion of the total tube surface. With increased air leakage this air cloud enlarges, making possible the further reduction in temperature of the mixture as it enters the air pipe. The correspondingly reduced vapor pressure permits the increase in air pressure and density necessary for the extraction of the increased amount of air with a constant volumetric pump capacity.

The temperature of the steam is not constant through the condenser. For the lack of a better method the average vapor temperature is usually assumed to be that of the exhaust steam. The greater temperature difference between cooling water and steam in the tubes through which the circulating water first passes, causes the heat transfer through these tubes to be much greater than the transfer in the last tubes reached by the circulating warmer water. Owing to this relatively higher heat flow in the first water pass, the actual mean temperature of this water is higher than that given by the arithmetical mean of the inlet and outlet temperatures. A logarithmic formula based on the allowable assumption that the rate of heat transfer is directly proportional to the temperature difference between the steam and water, is used when accuracy is desired in finding the mean temperature difference across the tube surfaces. For most purposes the simple arithmetical formula is found accurate enough.

Since the density of the air in the air-pump suction pipe can be determined from measurements of the total pressure and temperature, it requires but a simple calculation to find the amount of air leakage if the volumetric capacity of the air pump or ejectors is known.

Neglecting the effect of the total pressure drop across the tubes in lowering the vapor temperature, the lowering of the air-vapor mixture temperature in the air pipe is determined by the amount the vapor pressure must be reduced to permit the increase of air pressure. This depression is itself a good indicator of the amount of air leakage.

The difference between the exhaust and discharge circulating-water temperatures, which is nearly equal to the mean temperature drop across the tubes, may be used as a rough indicator of the total thermal head causing the heat transfer. As the mean temperature difference and the terminal drop vary with the rate of condensation, it is necessary to take this factor into consideration when comparing these temperature differences.

The coefficient in condenser work is obtained by dividing the product of the total pounds of steam condensed per hour and the total B.t.u. per pound of steam by the

product of the square foot of tube-surface area and the mean temperature difference. The total heat contained in a pound of steam as exhausted to the condenser can be determined by the following formula:

$$\textit{B.t.u. per lb. of exhaust steam} = \left(\textit{B.t.u. per lb. in steam at throttle}\right) - \left(3{,}415 \div \frac{\textit{Water}}{\textit{Rate}}\right)1.06$$

Variation of Flowing-Water Temperature Changes Heat Transfer Coefficient

The coefficient of heat transfer will be found to vary greatly with changes in the inlet circulating-water temperature. A small part of the variation usually found is due to the changed viscosity of the circulating water. If there were no air present in the condenser, the coefficient of heat transfer in water with 32 deg. inlet-water temperature would not be less than 88 per cent of the coefficient with 80 deg. F. inlet circulating water, but in practice where condensers are not kept tight the coefficient of heat transfer in winter is often less than half of the value obtained in summer.

Wide variations in the coefficient of heat transfer with changes in the circulating-water temperature are thus seen to be an indication of the presence of excessive amounts of air in the condenser. The changed resistance to heat flow from the water to the tube surface with changed inlet circulating-water temperatures, and hence changed total condenser pressures, is due to two causes. It is of course here assumed that the air leakage, and hence the density of the air around the air pipe, is the same in all cases.

With the lower absolute pressures resulting from lower circulating-water temperatures, the vapor pressure and volume are a great deal lower. The relative volume in winter is often only one-third as large as that in the summer. It can be seen that in this case there will be three times as many air molecules against the tube surface per unit number of steam molecules as was the case with summer conditions. Again, when working with lower absolute condenser pressures, a greater reduction in degrees is required to cause a one-tenth inch reduction in the vapor pressure.

Checking Thickness of Slime on Tubes

If the turbine load, air leakage and circulating-water temperatures and velocity could be held constant, changes in the coefficient of heat transfer would be due only to changes in the amount of slime or scale on the tubes. It is usually possible to obtain the same turbine load and circulating-water velocity when taking readings for determining the coefficient of heat transfer. It is then necessary to make allowance for changes in air leakage and inlet circulating-water temperature when comparing these coefficients to determine the condition of the heat-transfer surfaces. In making these allowances curves showing the absolute pressure to be expected at different inlet circulating-water temperatures and turbine loads will be found of assistance. These curves, which show the average results obtained from a number of condensers, can usually be obtained from the condenser manufacturers.

A great number of readers will, no doubt, feel disposed to question some of the statements herein made. It is hoped that they will feel free to make criticisms, as it is from the resulting discussions that our knowledge is broadened and our misconceptions erased.

Tests of Refrigerating Systems

By Charles H. Herter

A series of tests conducted by Constanz Schmitz at the expense of the German Linde Ice Machine Co., to determine the relative merits of dry compression and the flooded or accumulator system, is discussed in *Waerme-und-Kaelte-Technic*, Jan. 1, 1923.

Improved methods of operating ammonia compression machines effect an important saving in the horsepower required per ton of refrigeration. Tests demonstrating this fact have been made in the United States, but the tests Schmitz describes were made with the same equipment, and therefore the results facilitate a ready comparison of the different methods of operation. The full detailed log of ten different tests is given in the original publication, but only a condensed statement of the ultimate results is given here.

The tests were made on a 25-ton Linde machine in a cold-storage plant in Antwerp, Belgium. After introducing slight changes to reduce all tests to the same operating temperatures—namely, to a mean condenser-water temperature of 59 deg. F., a liquid temperature of 59 deg. and a mean brine temperature of 25.7 deg. —the following results were obtained:

Test III, covering the old standard Linde wet-compression system with rotating liquid distributor and with a discharge-pipe temperature of 134.6 deg. F., gave 1.038 indicated compressor horsepower per ton of refrigeration. This is called 100 per cent in comparing the several systems.

Tests I, II and IX, with wet compression but with unrestricted flow of liquid from a central stationary distributor and with a discharge-pipe temperature of 127.4 deg. F., gave 1.0135 i.hp. per ton, 97.5 per cent.

In tests VI and VIII the evaporator coils in the cylindrical brine-cooling tank were operated flooded and wet compression was used. The discharge-pipe temperature was 123.8 deg. F. and the indicated horsepower per hour was found to be 0.966, or 93 per cent.

Test X covered dry compression but without flooded coils. The discharge-pipe temperature was 183.2 deg. F. and the indicated horsepower per ton was 0.946, or 91.1 per cent.

In tests IV, V and VII dry compression was used in conjunction with flooded coils. The discharge-pipe temperature was 177.8 deg. F. and the indicated horsepower per ton of refrigeration proved to be 0.8455, or 81.5 per cent.

A saving in power consumption of 18.5 per cent over a normal standard machine should be considered worth while, but in the United States in more than half of all plants this saving is not taken advantage of.

Any consulting engineer or purchaser who is at all interested in the economical performance of ice and refrigerating machinery should see to it that either dry compression or the flooded systems, or both, are incorporated in their installations.

Turbine blades, when made of steel, may be corroded more readily by oxygen or acid than by alkali. Turbine blades of bronze and similar alloys often exhibit greater corrosion when alkali is present in the steam than when oxygen or acid conditions exist.

Evolution is very slow! Heidelberg man used fire 25,000 to 100,000 years ago, but the modern man is still wasting fuel.

Reminiscences of a Veteran Mechanical Engineer—IV

First Meeting with George H. Corliss; His Novel Pumping Engine and How It Was Nearly Wrecked

By W. H. ODELL

The preceding installments of these reminiscences were published in the June 19, 26 and July 3 issues and contained stories about the human side of some famous engineers of the sixties and seventies. The Hope Station test of George H. Corliss's engines, with which the present article deals, was one of the most exciting engineering controversies of that time. Power engineering on the Erie Canal, which was an all-absorbing topic among engineers of the seventies, will be the subject of the next number.

FOR some time I have thought to relate through the columns of *Power* a few of the incidents in the life of George H. Corliss that may interest present-day engineers, even though they may be more romantic than scientific. Like many other men who have placed their names high on the roll of fame as men who did things, creating as it were an epoch, Mr. Corliss was the target of the envious, if not malicious, but his name is secure for all time.

Even my old-time friend, William Wright, whose name I mentioned in a previous article in *Power*, often showed me a sketch of the Corliss valve, etc., which he originated in the early days when he, Mr. Wright, was superintendent of the Corliss works. If Mr. Wright was the original inventor of this valve, which became world famous, I have no means of proving, but this I do know, that that sketch was given to Fred R. Low by Mr. Wright's daughter shortly after Mr. Wright's death, and it is hoped that in due time it will be found among the relics of old-time engineers, now held by the American Society of Mechanical Engineers.

But regardless of this question, I also know Mr. Corliss had a wonderful insight into the details of the construction of his engines and boilers and was one of the few men who mastered the business side of making and selling his production. During my acquaintance of over twelve years, I never heard him use a profane word or indulge in abuse; but when occasion required, he was able to give the delinquent a very dignified reproval, one not soon to be forgotten.

My personal acquaintance with Mr. Corliss had its inception in 1873, as I recall the date. At that time one of his pumping engines was having a trial test at the Hope Station of the city water works in Providence, R. I. My reason for not filing the date definitely is that much of my data, drawings, notes, etc., were destroyed by fire many years ago, and there is nothing but memory to guide me.

This pumping engine was one of the most ingenious pieces of pumping machinery it was ever my good fortune to see. Briefly stated, it consisted of five Corliss steam cylinders and five pump cylinders, all in horizontal plane and connected to one crankpin on the end of a vertical shaft. Some of our younger engineers may wonder how such a machine could be arranged, ten connecting rods connected to one crankpin, and it is regretted that the loss of drawings, etc., previously

GEORGE H. CORLISS

referred to prevents giving an illustrated description. I hope this will reach the eye of some reader who has full descriptive matter and that he will favor the readers of *Power* with it. The engine was rated at 5,000,000 gallons capacity and was designed to meet unusual conditions.

The cause that led up to the building of this unusual machine related to a plan of the city engineer of Providence calling for the expenditure of several millions of dollars to build a reservoir and pumping station to supply a portion of the city known as the high-service section.

Mr. Corliss as a heavy taxpayer objected to such a large outlay of money, claiming that an engine could be built at a cost not to exceed $55,000, that would maintain a practically uniform pressure within the capacity of the pumping unit, on the distributing water

main without the use of a reservoir, standpipe or anything of like nature. And he did it.

The water came to the pumps under slight pressure and was boosted by the pumps to a pressure sufficient to supply the high-service section of the city. When delivering at the 5,000,000-gallon rate, the speed of the

GEORGE H. REYNOLDS

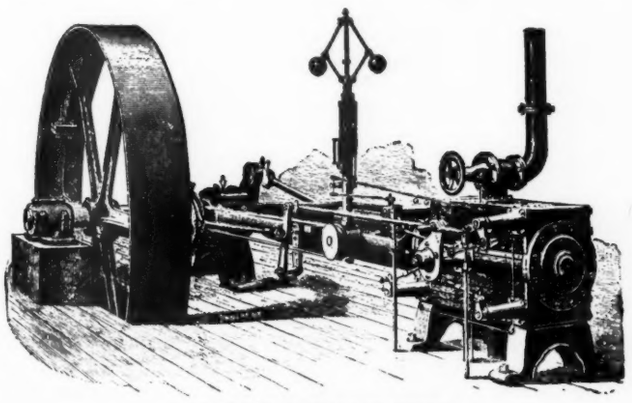
engine was 27 r.p.m., and from that speed it would automatically slow down to one revolution in 4½ minutes, varying but little from the latter rate between two and five o'clock in the morning.

The air pump was operated by a separate engine, which had an enormously heavy flywheel, and the whole outfit was regulated by the flow of water in the delivery main. The contract called for a test, and as the feeling was high between Mr. Corliss and his friends, and the city engineer and his friends, unusual care was exercised in the selection of experts to conduct the test. Mr. Francis, a famous hydraulic engineer of that day, was selected to conduct the riser measurement. George H. Reynolds, brother of Edwin H. Reynolds, then superintendent of the Corliss works, and later on to make a world-wide reputation in Milwaukee, represented Mr. Corliss; while Frederick Graff, another well-known hydraulic engineer, represented the City of Providence. The latter two agreed on Eustus W. Smith as the third member of the board.

Upon looking over the situation, Mr. Smith, in view of the intensely antagonistic feeling between the builder and the city engineer and the friends of both parties, suggested that due precaution be taken to disarm criticism that either party was being favored. As one of the important features of the test was to be the indicating of the steam performance, it was suggested that a specialist in that line be employed. At that time the writer was termed by his friends as the "steam sharp" of the old De Lamater Iron Works, of New York City, and George H. Reynolds, at that time consulting engineer of these works, suggested my name, which was acceptable to all interested parties, and it was while doing some indicating to satisfy my inquisitive nature, an event happened which carried me close to the heart of Mr. Corliss for many years.

One of the specifications of the test provided that the pumping units must be capable of drafting the water the equivalent of twenty feet when delivering at the 5,000,000-gallon rate. For this feature of the test it was arranged with the city fire department to attach hose to the hydrants to care for the surplus water until the full pumping capacity at 27 r.p.m. was reached; then a valve in the main that supplied the pumps was to be gradually closed until the desired lift was obtained.

Now just what happened will probably never be known, but at just the instant that I was taking an indicator diagram from the supply main, suddenly the engines began to race, and it seemed as if they would leave the premises or kill a number of persons, who were tumbling out of the doors and windows in their efforts to escape. It was said afterward by some who were present that there was no "Alphonse and Gaston" politeness shown just then, but each person was looking out for himself and no regard for the hindmost. There were so many persons who wished to see this test that a board fence had been built across the engine room to prevent the outsiders from interfering with the work of the experts. This fence was about six feet high and strongly built. Mr. Corliss chanced to be outside this fence when the engines started to race, and the crowd made a rush for the doors and windows. He immediately vaulted over the fence and shut off the steam from the engine, and came around back of the main engine, or pump, where I was at work. He was as white as chalk, and in answer to my question as to what had caused the trouble, he, in an excited tone, replied, "Mr. Odell, someone shut the water entirely off



CORLISS STEAM ENGINE

that engine; it could not get water and that was what made it run away."

I replied, "That is right, Mr. Corliss, and I have the proof right here," and showed him the diagram I had just taken, which showed a vacuum of over 27 inches. I will never forget how his face cleared as with a smile he reached out his hand and asked for the diagram. This request, much to my regret, I had to refuse, but I assured him that as it was no part of the data of the test I would keep it carefully, and in the event of the case being carried to the courts, he could

summon me and I would gladly produce it. This little incident, as well as subsequent ones, led me to believe Mr. Corliss reposed much confidence in me.

But to return to the question of shutting off the water supply. To avoid any difference of opinion with others who may be familiar with the circumstances, and to give opportunity for others to theorize, I will state that it was arranged to have a laborer in the water department at the shutoff valve in plain sight of the engine room during the suction, or lifting trial. When the engine reached a speed of 27 r.p.m., this laborer was, on signal from the engine room, to close down the valve until the desired lift was obtained. Just as the desired point was reached, one of the experts dropped his handkerchief, and Mr. Corliss, who had been told of

NATHANIEL GREENE HERRESHOFF

this, thought it was a prearranged signal for the laborer to give a quick turn to the valve, and thus wreck the engine. Whether he ever changed his opinion about this I do not know, for it was a delicate subject to refer to in his presence, but personally, I have always thought the stoppage of water was due to anchor ice, of which there was plenty in the water, and some of it may have jammed against the partly closed valve, and thus accidentally shut off the water supply. The high grade of the men conducting the tests rather forbids the thought that any of them could do anything to wreck the engine and jeopardize the lives of many people.

But to forestall the question as to why the governor did not take care of the engine in such an emergency, it may be well to state that the governor of the auxiliary engine had been tested, and adjusted up to the full capacity for which it was designed, and it worked perfectly up to that point; but the sudden cutting off of the water caused the governor to overreach and thus cause the trouble. But to explain in detail how this could happen, without the aid of drawings, would make this article too long.

It was at this test I also met for the first time N. G. ("Nat") Herreshoff, who in later years became the world's most famous builder of fast sailing yachts, etc., and who was at that time considered one of the brightest men employed by Mr. Corliss; and there were a lot of them who later on wrote their names high up on the lists as mechanical engineers. It was Mr. Herreshoff who designed and fitted the engines with reducing motions for indicating, and doubtless he could, if properly approached, give a most interesting account of the construction of the engine.

For several years previous to his death Mr. Corliss had contemplated building a small unit boiler as a companion for his well known "rolling pin boiler." Later on, when the works had passed into other hands, a boiler of this type was built and proved wonderfully economical, but practically a failure on account of its revolving grate, which, as far as I know, was not the original plan.

In the late summer of 1896 I was engaged by the builders of the boiler to experiment with different forms of grates and proportions of grate to heating surface, and the result was so surprising that it was questioned. As a result Dean & Main, of Boston were engaged to check up the tests. As a "cud to chew on" I will present a summary of the results.

When Mr. Dean came to the fire room Sept. 10, 1896, I told him I was subject to his orders and asked for instructions. The reply was, "You please continue in charge and run today's test, and I will be a mere looker-on and take notes."

The summary of this test as taken from an old log book, follows:

Pounds water per pound dry coal	10.23
Pounds water per pound combustible	10.99
From and at 212 deg. F. per pound dry coal	12.14
From and at 212 deg. F. per pound combustible	13.49

As there was some controversy over these figures a second test was run the next day, Sept. 11, with the following results:

Pounds water (70 deg.) per pound dry coal	10.52
Pounds water (70 deg.) per pound combustible	11.45
From and at 212 deg. F. per pound dry coal	13.46
From and at 212 deg. F. per pound combustible	13.63

Later on, other experts were called on to run tests, but some changes had been made and they did not get quite so high duty, but if I may be pardoned for venturing a suggestion, I should say that it was in great part due to different temperatures of the external air.

[The evaporation shown would correspond to a boiler efficiency which would appear doubtful under the conditions. We are printing the figures as given by Mr. Odell, however, subject to subsequent discussion.—Editor.]

Turbine vibrations may be primary or secondary in their character. Some of the most common causes of primary vibration are faulty shop work or erection, deflection of spindle, excess bearing clearance, improper fit of bearing in housing, and admitting air through glands. Secondary vibrations may be caused by rubbing or loss of blades, local heating due to rubbing of packing or sealing rings, wedging of spindle by fused metal, distortion of cylinder casing by expansion of steam pipes, lack of rigidity in the rotor due to improper fitting of component parts, warping of blade rings, etc.

Small Plant Equipped for Extensive Tests To Check Weekly Performance

By J. W. GEIGER and H. L. SOLBERG*

ECONOMIZERS and feed-water heaters used in connection with four 3,000 sq.ft. 150-lb. boilers, are equipped for frequent testing. Automatic damper control regulates the supply of warm air from the drying room. One condensing and two 35-lb. back-pressure Corliss engines drive the process machinery. Changes in engine load supply variable demand for exhaust steam in almost correct proportions. The weekly calculation of boiler performance is checked by extensive tests from time to time and exceptionally high efficiencies have been recorded.

EXTENSIVE tests of the plant of the Lafayette Box Board and Paper Co., of Lafayette, Indiana, are conducted from time to time, the weekly plant performance is determined and much time is devoted to a study of the heat balance with the result that the efficiency of the plant is exceptionally high. The average equivalent evaporation per pound of coal as fired, extending over a period of one year, is 10.616 lb. of water, with an average boiler-room efficiency of 76.8 per cent. Combined boiler and economizer efficiencies of over 84 per cent have been obtained during tests.

In order to understand some of the special features that contribute to the high efficiency of the plant, it is advisable to consider briefly the method by which paper board is manufactured from straw. Straw is elevated and dumped into spherical rotary digesters, of which there are 18, each 14 ft. in diameter, having a capacity of about 7 tons of straw. After being cooked for about ten hours with lime and steam at 35 lb. pressure, the straw is discharged to a storage room, where it remains about ten days until the chemical reactions between the lime and straw are completed.

From the storage room the raw fiber is conveyed to one of eight beaters, where the lime is washed from it and it is then reduced to a pulp by being passed between a stationary plate and teeth on a rapidly revolving drum. The pulp is next conveyed to one of four refining machines. After passing over screens to remove any foreign matter, it is ready for manufacture into strawboard. Process steam is therefore required as well as power for driving the machinery.

The paper machine contains two belts of wool felt, operating one above the other. Four layers of pulp are deposited on the upper side of the lower belt while two layers are deposited on the lower side of the upper one. These belts are forcibly pressed together with the six layers of pulp between them. They are then separated, and the wet paper board is taken from between and passed through 97 drying rolls containing steam at about 35 lb., where the paper is thoroughly dried; 60,000 cu.ft. of hot air with a relative humidity of 55 per cent is supplied per minute to the drying room. From the drying rolls the product is passed through the finishing rolls to the cutters, where it is reduced to commercial sizes ready for shipment and manufacture into paper boxes. The engine room contains three Corliss engines, supplied with steam at about 150 lb. gage. A 450-hp. cross-compound condensing Corliss engine, exhausting into a surface condenser, drives the beaters and washers. A 150-hp. Corliss engine, operating against a back pressure of about 35 lb., drives the 18 rotary digesters, conveyors and a 60-kw. generator. A 350-hp. twin-cylinder Corliss engine, exhausting at about 35 lb., drives the refining machines and also the paper machine, drying and finishing rolls and cutters, through a variable-speed drive. In order to secure a uniform product it is necessary that the forming machine and drying rolls be driven at uniform speed. Fig. 1 is a reproduction of a chart obtained from the recording tachometer on the twin-cylinder Corliss engine driving these machines and illustrates the close speed regulation of this engine.

Exhaust steam from the two non-condensing engines is supplied to the rotary digesters and to the drying rolls. No direct provision is made regarding the variation in demand for exhaust steam. However, an increased demand due to a larger number of digesters being in use, is accompanied by a greater load on the engine. A heavier paper passing through the drying rolls requires more steam at a higher pressure in order to dry it, which increases the load and back pressure on the twin cylinder engine and therefore the steam consumption. Consequently, the variable demand for exhaust steam is taken care of automatically; only on rare occasions is it necessary to admit much live steam to the drying rolls, and there is seldom an excess.

The boiler room contains four 3,000-sq.ft. Stirling boilers, each equipped with an underfeed stoker having a grate surface of 57.5 sq.ft. The boilers are set in pairs. Each setting is covered with from two to three inches of asbestos, and a canvas jacket, being inclosed in a sheet-metal casing. Inspection doors are sealed with plastic asbestos.

The boiler plant is equipped with the Carrick system of combustion control. A decrease in boiler pressure opens the main damper at the induced-draft fan, by an amount proportional to the decrease in pressure. The resulting increase in draft in the furnace causes a regulator to open a damper in the forced-draft air duct until the draft over the fire is reduced to zero again. This system operates very smoothly and satisfactorily and maintains a practically constant steam pressure on the boilers at all times as well as at the engines.

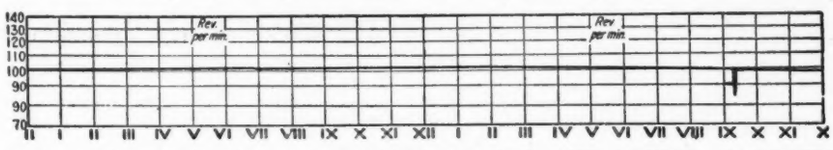


FIG. 1—SPEED OF ENGINES DRIVING FORMING AND DRYING MACHINES

*Instructors in Mechanical Engineering, Purdue University.

Air for the forced-draft fans is taken from the drying rooms and consequently is at a much higher temperature than the air in the boiler room, and also has a higher relative humidity. The point well illustrates the manner in which advantage has been taken of every favorable condition in the plant by means of which the efficiency might be increased.

Coal from hopper-bottom cars is discharged into a track hopper, from which it is fed by gravity to a crusher. It is then elevated to overhead bunkers by means of a bucket conveyor running over the bunkers and under the boiler-room floor, parallel to the firing aisle. Ash is elevated to an overhead bin by the same conveyor and is discharged into dump wagons.

Feed-Water Heater and Economizer Are Equipped for Tests

All returns are collected in a receiver located above an open feed-water heater. Makeup water amounts to from 3 to 10 per cent of the total boiler feed. About 2½ per cent is lost in blowing down the boilers. Nearly all the remaining makeup water required is due to the fact that the exhaust steam used in the rotary digesters cannot be recovered, since it comes into contact with the straw. The raw water required for boiler feed makeup is treated in a hot-process water softener, using lime and soda ash.

Water from the heater is pumped through a venturi meter and an economizer before entering the boilers. The venturi meter is of the integrating, recording and indicating type. Four measuring tanks are permanently located above the feed-water heater for measuring the water fed to the boilers when tests are being conducted or the venturi meter is being calibrated.

Recording thermometers give the temperature of the feed water entering and leaving the heater and the economizer; also the temperature of the flue gases leaving the boiler, entering and leaving the economizer. Each boiler is equipped with a steam-flow meter, indicating in the boiler room and recording in the office. The boiler room also contains pressure-recording instruments and a CO_2 recorder.

Results of Tests

It is the policy of the company to conduct frequent tests for the purpose of determining boiler-plant performance and the accuracy of recording instruments. Table I shows the results of three made immediately after the installation of the present stokers. In all such tests the coal is weighed in wheelbarrows and the water is measured in permanent measuring tanks located over the feed-water heater. In the second and third tests in Table I, coal was taken from storage, while in the first test coal was obtained from the bunkers. Lorado, West Virginia, screenings were used throughout. The ultimate analysis given in this table was obtained by mixing the coal samples from each of the three tests and averaging the results secured from an analysis of this sample made by three different chemists.

The results are of considerable interest as they show a boiler efficiency of from 78.5 to 80 per cent and an over-all boiler and economizer efficiency of about 85 per cent. When it is remembered that these Class A

TABLE I—OFFICIAL ACCEPTANCE TESTS OF WESTINGHOUSE FOUR-RETORT, UNDERFEED STOKERS UNDER FOUR CLASS A, 3,000 SQ.FT. STIRLING BOILERS AT LAFAYETTE BOXBOARD AND PAPER COMPANY

Test number	1	2	3
Date	5/13/21	5/17/21	5/19/21
Test number	1	2	3
Date	5/13/21	5/17/21	5/19/21
Duration of test, hours	8	8	8
Number of boilers	4	4	3
Total water-heating surface, sq.ft.	12,000	12,000	19,000
Total grate surface	230.28	230.28	172.71
PRESSURES, TEMPERATURES, ETC.			
Steam pressure, by gage, lb. per sq.in.	143	143.4	143.2
Temperature of feed water entering boilers, deg. F.	252.3	253.4	265.7
Temperature of feed water entering economizer, deg. F.	199.6	197.5	196.8
Temperature of gases leaving boiler, deg. F.	540.4	538.7	587.0
Temperature of gases entering economizer, deg. F.	520	520	552.1
Temperature of gases leaving economizer, deg. F.	286.5	301.5	313.8
Temperature of coal, deg. F.	73.4	84.0	93.8
Temperature of air entering furnace, deg. F.	92.8	94.2	101.8
Per cent of moisture in steam	0.68	0.74	0.57
TOTAL QUANTITIES AND RATES			
Total weight of coal as fired, lb.	33,100	34,453	32,157
Per cent of moisture in coal	5.6	4.99	4.33
Total weight of dry coal, lb.	31,246	32,734	30,765
Slag, ash and refuse, lb.	3,530	4,399	3,916
Per cent of ash and refuse, based on dry coal	11.30	13.44	12.73
Total weight of water fed to boilers, lb.	382,121	373,178	349,950
Water actually evaporated, corrected for moisture, lb.	379,842	370,723	348,556
Total equivalent evaporation, from and at 212 deg. F., lb.	402,253	392,154	372,244
Equivalent evaporation from and at 212 deg. F., per lb. of coal as fired, based on boiler and economizer, combined	12.15	11.38	11.58
Equivalent evaporation from and at 212 deg. F., per lb. of dry coal, based on boiler and economizer, combined	12.87	11.98	12.10
Equivalent evaporation per hour from and at 212 deg. F., per sq.ft. of water-heating surface, lb.	3.97	3.87	4.78
Dry coal burned per sq.ft. of grate surface per hour, lb.	16.9	17.77	22.3
Per cent of rated capacity developed	121.5	118.4	149.9
ANALYSIS OF FLUE GASES			
Carbon dioxide, per cent	14.08	14.64	13.98
Oxygen, per cent	4.92	4.36	5.02
Carbon monoxide, per cent	0.00	0.00	0.00
Nitrogen, per cent (by difference)	81.00	81.00	81.00

PROXIMATE ANALYSIS OF COAL			
Moisture, per cent	5.6	4.99	4.33
Volatile, per cent	33.0	27.85	28.54
Fixed carbon, per cent	58.58	60.09	60.42
Ash, per cent	8.42	11.30	10.25
Sulphur, per cent	0.85	0.76	0.79
B.t.u., dry	14,720	13,643	13,792
B.t.u. as fired	13,916	12,962	13,194
ULTIMATE ANALYSIS OF COAL			
Carbon (ash and moisture free), per cent	.....	86.41	.....
Hydrogen (ash and moisture free), per cent	.....	5.30	.....
Oxygen (ash and moisture, free), per cent	.....	5.80	.....
Nitrogen, per cent	.....	1.61	.....
Sulphur, per cent	.....	0.88	.....
$CO_2 + O_2 = 19\%$			
ANALYSIS OF ASH, DRY BASIS			
Combustible	25.60	15.93	19.5
Ash	74.40	84.07	80.5

HEAT BALANCE

	B.t.u.	Per Cent	B.t.u.	Per Cent	B.t.u.	Per Cent
Heat absorbed by boiler alone	11,757.0	19.88	10,947.6	80.24	10,834.4	78.53
Loss due to evaporation of moisture in coal	74.9	0.51	65.7	0.48	57.2	0.41
Loss due to heat carried away by steam formed by the burning of hydrogen	551.9	3.75	529.6	3.88	541.4	2.93
Loss due to heat carried away by dry flue gases	1,475.5	10.02	1,380.5	10.12	1,585.7	11.5
Loss due to CO	0.0	0.0	0.0	0.0	0.0	0.0
Loss due to combustible in ash and refuse	419.1	2.84	310.3	2.28	262.5	2.63
Loss due to combustible carried away in flue gases, radiation and unaccounted for	441.6	3.00	409.3	3.00	413.8	2.00
Total calorific value of 1 lb. of dry coal	14,720	100.00	13,643	100.00	13,792	100.00
OVERALL EFFICIENCY						
Heat absorbed by economizer alone	[illegible]	4.37	646	4.73	814	5.90
Combined boiler and economizer efficiency	....	84.25	.....	84.97	.....	84.43

Stirling boilers are set only 2 ft. 3 in. above the floor, these results are indeed remarkable.

Besides the tests that are conducted from time to time to check the accuracy of recording instruments, weekly records are obtained from which a heat balance is calculated and posted in both the engine and boiler rooms. Table II shows such a heat balance, covering a period of four weeks selected at random, and shows clearly the exceptional average performance obtained from the plant. The quantity of water evaporated per week is determined from the venturi meter. Coal consumption is obtained by means of revolution counters on each stoker. Lorado, West Virginia, screenings are used exclusively, except during the recent coal shortage,

TABLE II—WEEKLY HEAT BALANCE RECORD

Boiler performance for week ending.....	4/15/22	4/22/22	4/27/22	5/6/22
Temperature of feed water entering economizer, deg. F.....	195	200	200	203
Factor of equivalent evaporation.....	1.0635	1.0579	1.0579	1.0548
Actual evaporation per lb. of coal as fired	10.37	10.12	9.99	10.37
Equivalent evaporation from and at 212 deg. F., per lb. of coal as fired.....	11.01	10.70	10.56	10.93
Total heat absorbed per lb. of coal as fired, B.t.u.....	10,684	10,383	10,247	10,606
Heat value of dry coal.....	13,867	13,867	13,867	13,867
Moisture, per cent.....	4.2	4.2	4.2	4.2
Heat value of coal as fired.....	13,286	13,286	13,286	13,286
Over-all efficiency of boiler and economizer.....	80.3	78.2	77.3	79.8

and numerous tests have shown that the stokers deliver an average of 77½ lb. of coal to the grates per revolution of the crankshaft. Samples of coal are removed from the hoppers daily and about once a month are sent to a chemist for analysis. All other data necessary for the calculation of a heat balance are obtained from the recording instruments. The over-all boiler and economizer efficiency is seen to be nearly 80 per cent.

In order to determine the average performance of the plant over a considerable period of time, the writers examined the log of the chief engineer and compiled the data of weekly performances. As the plant operates twenty-four hours in the day except Sundays, when it

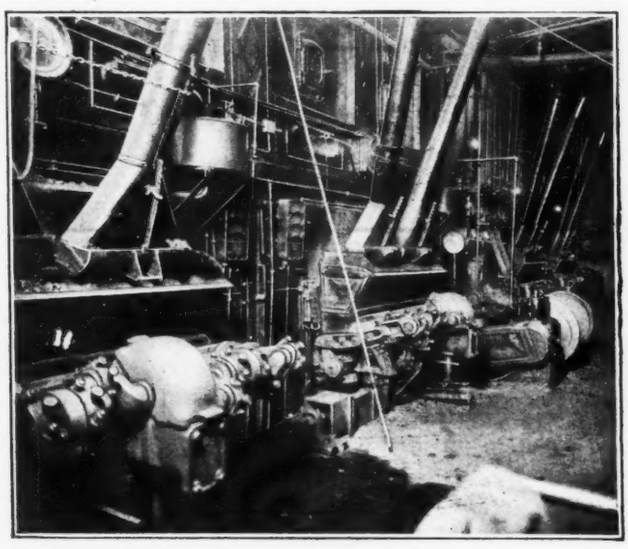


FIG. 2—UNDERFEED STOKERS SUPPLY FOUR BOILERS OF 3,000 SQ.FT. HEATING SURFACE EACH

is shut down, this includes the coal and water consumed between 6 a.m. Monday and 6 a.m. Saturday, thereby eliminating stand-by losses which are irregular, and thus giving the actual performance of the plant under normal operating conditions. Weeks in which the plant was shut down at any time between Monday and Saturday have not been included.

The water fed to the boilers was obtained from the venturi-meter readings, which are recorded every day at 6 a.m. Coal consumption was obtained by allowing 77½ lb. per revolution of each stoker crankshaft, as already explained. Average boiler output was obtained from the steam-flow meters. This result is subject to two possible errors—that due to inaccuracy in the venturi meter and that due to error in the assumption that 77½ lb. of coal is fired per revolution of each

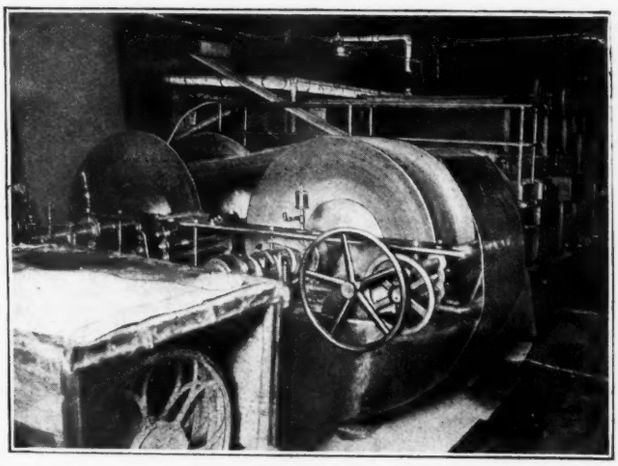


FIG. 3—VARIABLE-SPEED DRIVE CONNECTS 350-HP. ENGINE WITH PROCESS MACHINES

stoker. The venturi meter has been calibrated over thirty-five times in the last twelve years, and only once was it found to be in error more than 2 per cent. With regard to coal consumption the average of 77½ lb. per revolution of the stoker is the average of many tests and may be taken as a fair value, inasmuch as all coal comes from the same mine.

The average evaporation per pound of coal as fired, taken from these calculations, is 10.035 lb. for the 11½ month period, although the weekly evaporation ranged from 8.96 to 10.7 lb. Assuming that the feed water enters the economizer at an average temperature of 200 deg. F. and that the average boiler pressure is 150 lb. gage, this gives an equivalent evaporation from and at 212 deg. of 10.616 lb. of water per pound of coal as fired. The average heat value of the coal used, taken from the analyses by the chemists and extending over this period, is 13,414 B.t.u. per lb. as fired. This gives an average combined boiler and economizer efficiency of 76.8 per cent for practically one year.

Credit for this remarkable record must be given to Thomas Bauer, the owner of the plant, who has devoted much time and thought to a study of the heat balance and preventable losses. Too often, the power plant of a manufacturing company is regarded as a necessary evil, the sole function of which is to generate steam. The results obtained from this plant show that the efficiency of the average power plant may be increased very much if given the same careful consideration and attention that is given to directing manufacturing processes.

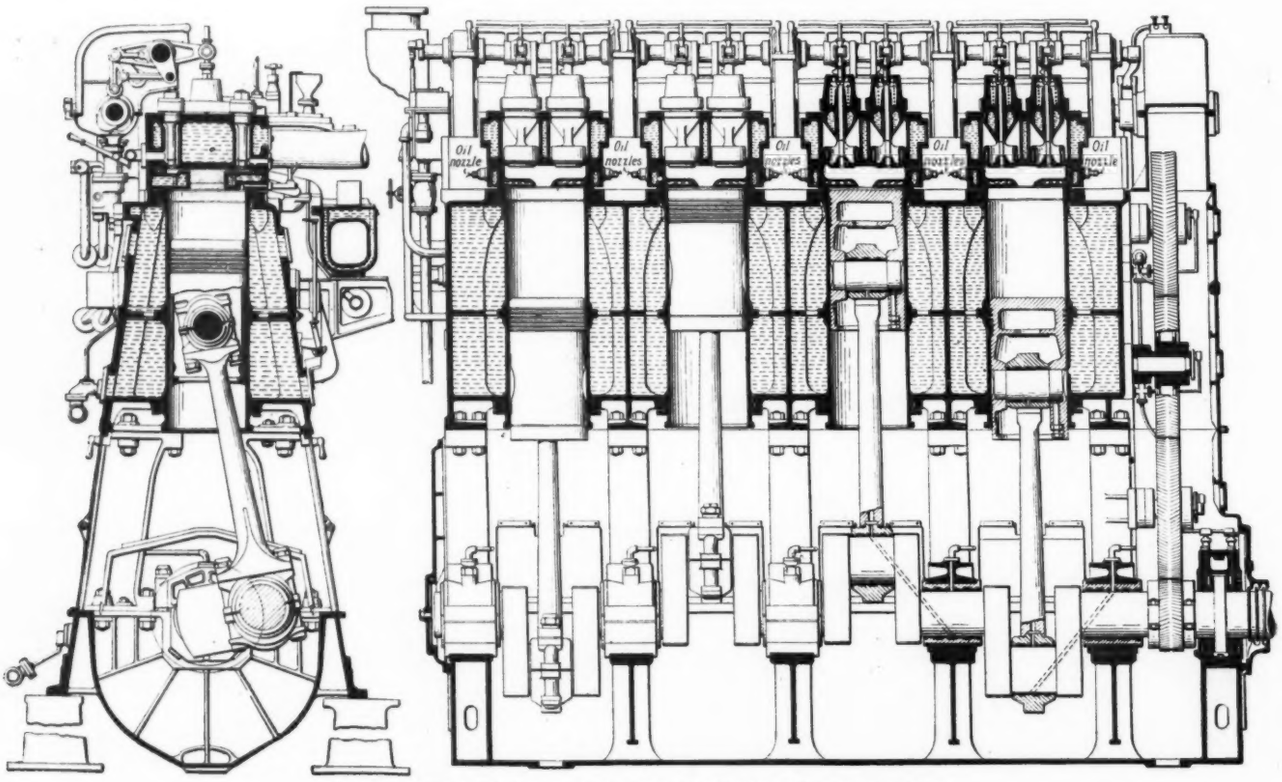
The writers wish to express their appreciation to W. T. Miller, superintendent, and H. H. Keller, chief engineer, for the many courtesies extended to them and for the data that appear in this report.

Dr. Asten, of Cambridge, claims that the energy liberated in transmuting the hydrogen in a teaspoon of water into helium is equivalent to 200,000 kw.-hr. Some power!

A New Heavy-Oil Engine

The Falk Corporation has brought out a 550-horsepower solid-injection oil engine. For marine propulsion four engines drive one propeller through reduction gear.

THAT there is a growing sentiment among internal-combustion engineers that the solid-injection oil engine has a well-defined status as a prime mover is evidenced by the adoption of this principle by the Falk Corporation, in its new four-cylinder vertical engine, which is designed for both stationary and marine service. In order to adapt the engine to a slow-speed propeller, four of these units are connected through reduction gearing and flexible couplings to a single shaft, which at the Falk factory drives a generator for loading purposes. For stationary service the single engine will be direct connected to a generator or arranged for belt drive as local conditions may dictate.



CROSS-SECTION OF FALK SOLID-INJECTION OIL ENGINE

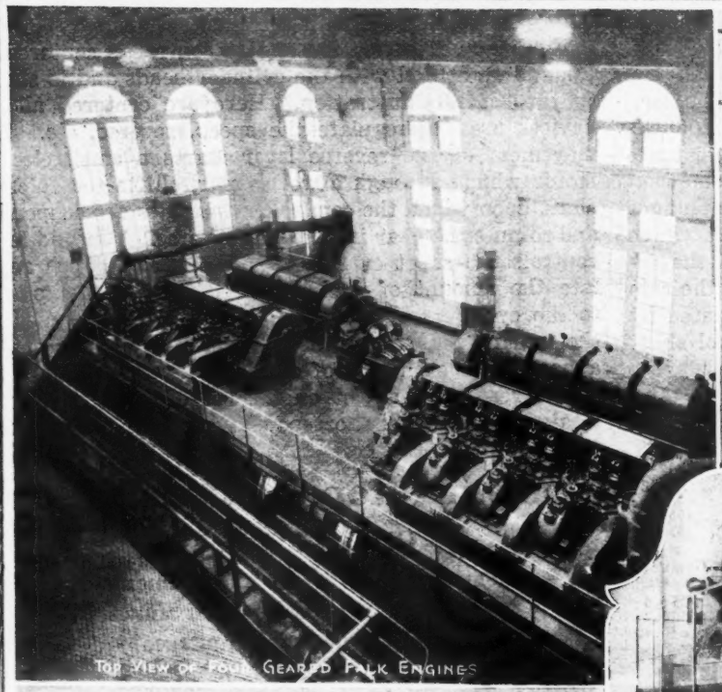
The vertical design includes a one-piece sub-base which also acts as a crank oil pan. Upon this sub-base is mounted the cast steel box frame. This is in outline a series of vertical and horizontal girder members, which design provides for ample room for inspection doors, etc.

The cylinder liners are set into a cast-iron box or tank which in turn rests on the upper surfaces of the frame columns, and the space between the liners and the box walls acts as the cooling water jacket. The box also acts as the tension member in transmitting the head pressure to the frame. The liners protrude through the lower end of the box, but leakages are prevented by stuffing boxes around the liners. As an additional support a plate extends across the center of the box and bears against the liners.

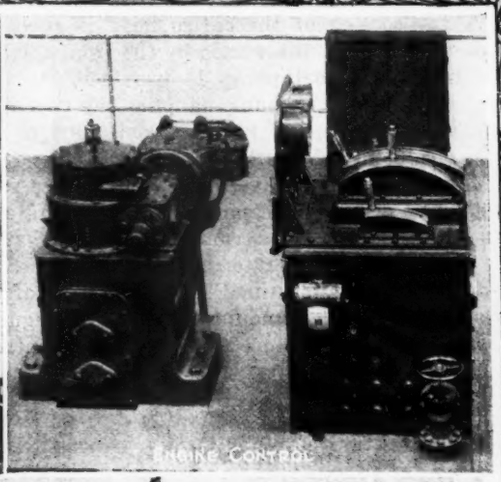
In order to insure good combustion at medium compression pressures, the fuel is not introduced into a clearance space between the piston and cylinder head as is usual with air-injection Diesels. Instead, the combustion space is a cavity formed in the cylinder head and is in communication with the cylinder proper by a wide passage. The head is made in two pieces, the top piece having a plain bottom, which forms the top of the combustion cavity and contains the admission and exhaust valves. The second piece has formed in it a wedge-shaped cavity and a central passage extending through the casting.

The piston on the compression stroke forces the cylinder charge of air through the connecting passage into the combustion cavity. Two atomizer nozzles placed at opposite sides of the cylinder head inject the fuel charge by the action of the fuel pump. While the pressure is lower than in an air-injection Diesel, being about 350 lb. per sq.in., the heat loss to the combustion chamber walls is such that the air-charge temperature is ample to ignite the oil upon introduction. The two atomizers inject two sprays of oil which, meeting at the center of the cavity, create a turbulence of the air and oil which insures thorough intermixing and complete combustion.

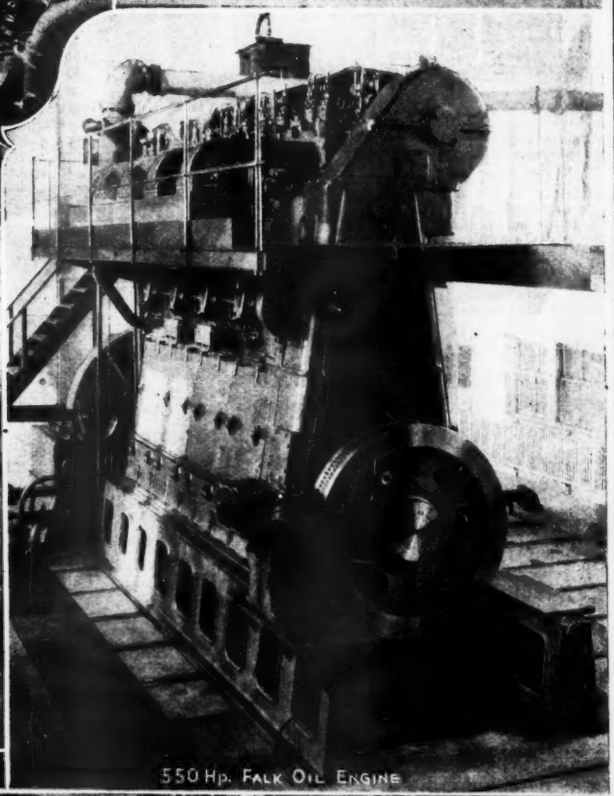
The separate combustion-chamber design has the additional merit that the piston is not subjected to the radiant heat developed during the combustion period



Top View of Four Geared Falk Engines

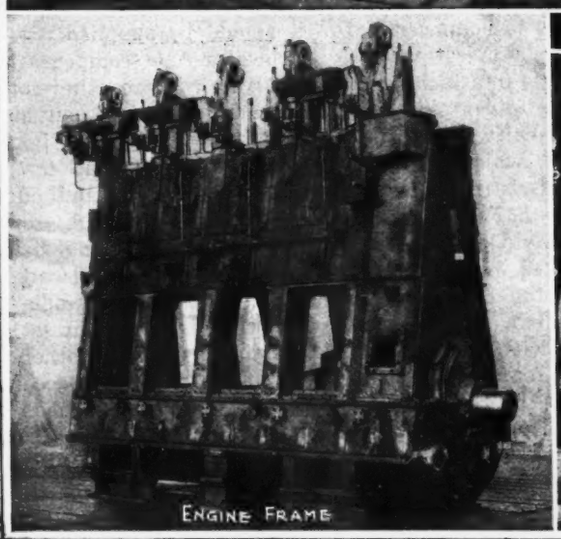


Engine Control

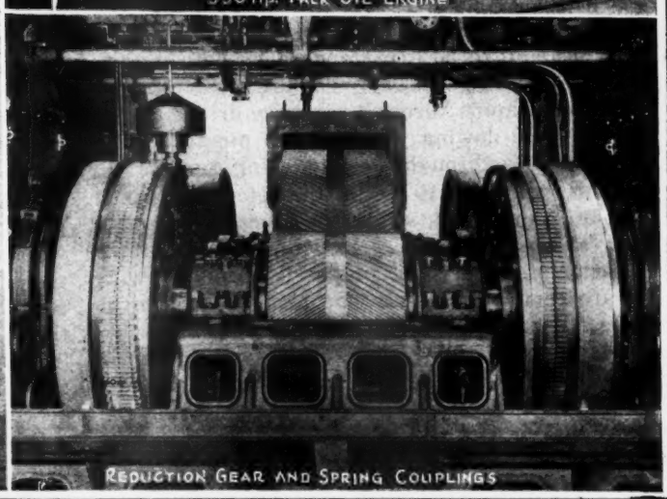


550 Hp. Falk Oil Engine

Bedplate with Crankshaft



Engine Frame



Reduction Gear and Spring Coupling

and consequently piston-head fracture should not occur. The water cooling of the entire head is such that the stresses due to heat absorption by the iron walls are low.

An individual fuel pump is provided for each cylinder; in this way one pump supplies the two atomizers. The atomizing pressure ranges from 3,000 to 4,000 lb. per sq.in., although with viscous oils the resistance may cause the pump delivery pressure to rise somewhat above these values. The pump is of the single-plunger type, being driven by a cam on the camshaft which runs along the cylinder tops. The timing of the injection period is determined by the position of the cam on the camshaft, the amount of oil being regulated by a bypass operated by an eccentric on the control shaft

SUMMARY OF ENGINE TESTS

Duration of test, hours	3
Load of generator, electric hp	2,073
Efficiency of generator, per cent	92.5
Load on flange on low-speed gear, hp	2,240
Total fuel consumption in three hours, lb	2,851
Fuel consumption per b.hp.-hr., lb	0.424
Speed of low-speed shaft, r.p.m	88.3
Indicated horsepower, four engines	2,695.4
Mechanical efficiency of engines and gear, per cent	83.1

	Starboard Engines		Port Engines	
	Fore	Aft	Fore	Aft
Exhaust temperature, deg. F	609.7	589.4	629.0	571.6
Cooling water, deg. F	121.0	120.5	120.3	120.4
Indicated hp	669.00	672.00	674.00	680.40

Temperature of:	
Cooling water at inlet, deg. F	38.5
Fuel oil in measuring tanks, deg. F	88.1
Lubricating oil at inlet, deg. F	98.0
Lubricating oil at tank, deg. F	103.0
Pressure of:	
Lubricating oil at pump, lb	15.8
Lubricating oil at engines, lb	8.1

below the camshaft; for stationary work this shaft will be under direct governor regulation.

The exhaust and admission valves are operated by rocker arms whose rollers bear against cams on the camshaft. For marine service two sets of cams are provided, and at the end of the rocker arm is placed a triangle with two rollers; by manipulation of the reverse control the triangle is shifted to bring the proper roller under the ahead or reverse cam as the case may be.

The crankshaft, although 11½ in. in diameter, is a one-piece forging with the four cranks set in one plane, the firing order being 1-2-4-3. The shaft bearings rest in the cross-girders of the sub-base; the lower bearing half has milled sides at right angles to the flat bottom of the shell. The bearing thus sits solidly into the housing without any tendency to rotate with the shaft. To remove the bearing, the shaft is raised sufficiently to permit the bearing to be lifted and rolled out. Lubrication of the bearings is by pressure feed, the oil reaching the crankpins through passages drilled in the shaft and likewise flowing to the piston pin through a hole drilled entirely through the connecting rod.

The piston, which is 19 in. in diameter and has a 28-in. stroke, is provided with six sealing rings and a wiper ring at the lower end. No water cooling of the piston is attempted, as the diameter is such that with the separate combustion space the heat absorption of the head is not dangerous.

Although the reduction gearing is for marine work exclusively, it is of considerable interest to the landsman. The engine speed is 220 r.p.m., and to bring the propeller speed down to normal the reduction gear was necessary. In the marine set installed at the Falk factory, each pair of engines are connected in line and are connected to the reduction pinion through Bibby-Falk spring couplings. The two pinions mesh with the reduction gear, which is connected to the propeller shaft. The gear set is shown in the illustrations.

For marine service the engine control is centered in a stand on a level with the cylinder heads and is shown in the control illustration. Here are centered all the devices used to regulate the speed, reverse, etc. The movement of the reverse lever starts a small electric motor which, through a worm gear, shifts the fulcrum shaft upon which the cam roller triangles are suspended and so puts the gear in ahead or reverse. A second lever controls the shaft carrying the eccentrics which regulate the amount of fuel delivered by the fuel pumps to the cylinders. Two air-starting levers are used on the marine set, each lever controlling the air-starting apparatus of each pair of engines.

The results of a test on the set of four engines, a total of 2,200 rated horsepower, are given in tabular form.

Hoisting-Rope Compensation on Elevators

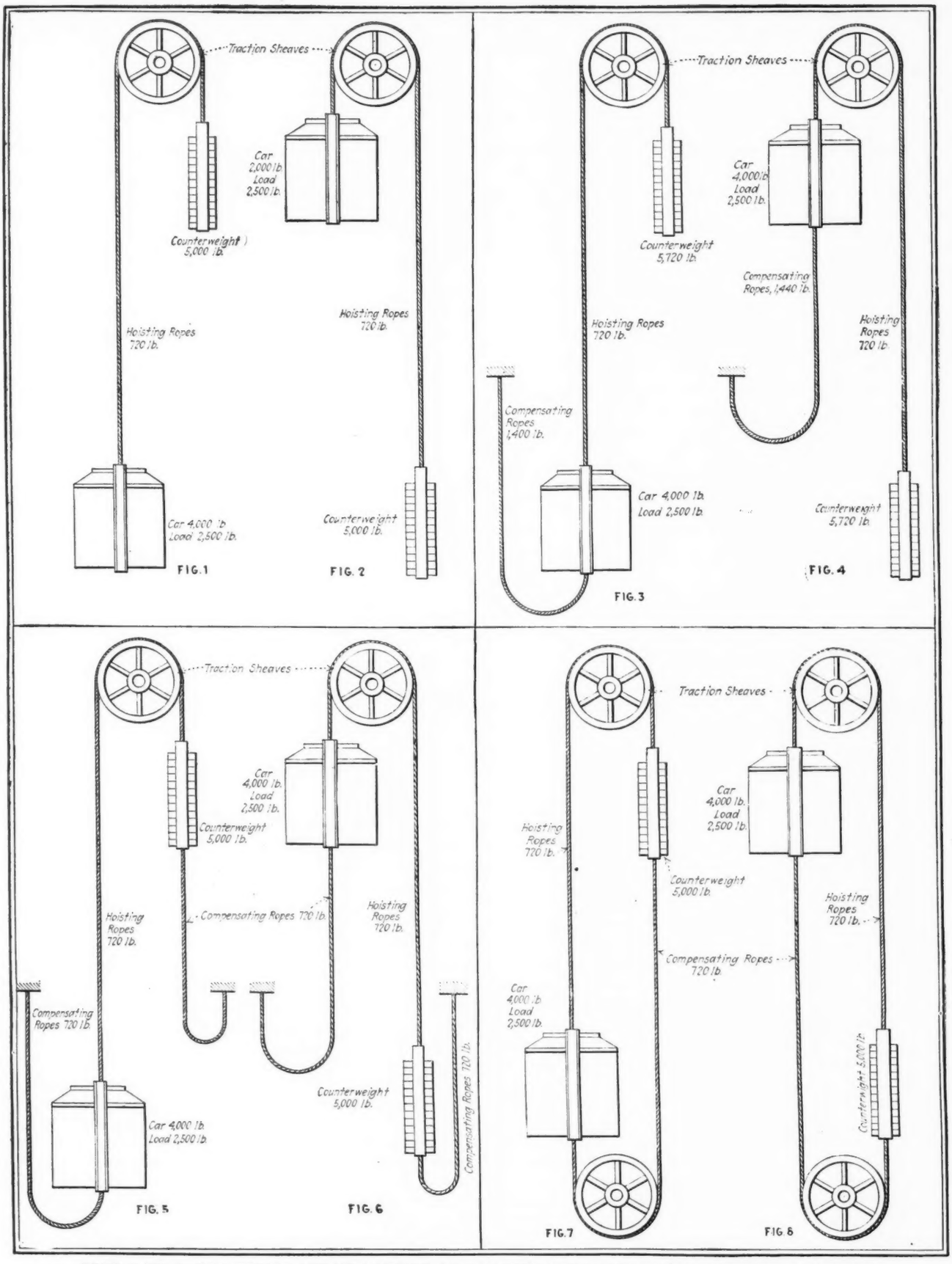
Compares the Various Arrangements of Compensating Cables and Shows Their Relative Advantages

By A. A. Gazda
Manager, Engineering Department, Kaestner & Hecht Company, Chicago, Ill.

Without any form of compensation the load on an elevator machine or motor will not be constant during a run from the bottom of the hatch to the top. Starting at the first floor, Fig. 1, the motor must not only lift the difference in weight between the car and the counterweight, but in addition must raise the weight of the ropes included between the limits of travel. As the car approaches the top floor, Fig. 2, the effective weight of the ropes is transferred to the counterweight side with the result that the load on the motor is reduced by twice the weight of the ropes. In other words, the weight of the ropes, which is added to the weight of the car and load in Fig. 1, is added to the counterweights in Fig. 2. With a rise of only a few floors this change in load is not important enough to warrant any special consideration. On the other hand, if a rise of 100 ft. or over is involved, this factor becomes quite appreciable and means to compensate for it should be supplied.

The simplest method of elevator-rope compensation consists in attaching one end of the compensating ropes to the under side of the car and the other end at a point halfway up the shaft. This is seen in Figs. 3 and 4, which show the car at the bottom and top of the hatch respectively. A variation of this method is given in Figs. 5 and 6, where the compensating ropes are divided into two independent parts, one being attached to the car and the other to the counterweight, while the free ends of each are fixed at the middle of the hatch. Another method consists in using one set of ropes with one end attached to the car and the other to the counterweight, as in Figs. 7 and 8. Before proceeding to the relative advantages of the three methods, a typical problem with its solution for each method will be considered.

Assume a load of 2,500 lb. in a car weighing 4,000 lb. The counterweight should balance the weight of the car and in addition 40 per cent of the load, giving a total of 5,000 lb. for the counterweight. A conservative design of the hoisting ropes would specify six ⅝-in



FIGS. 1 TO 8—DIFFERENT ARRANGEMENTS OF COMPENSATING CABLES ON ELEVATOR MACHINES

Figs. 1 and 2—Traction elevator machine without compensating cables. With full load in car, load on motor varies from 1,500 lb. with car at bottom landing to 780 lb. at top landing. Figs. 3 and 4—Compensating cables connected from car to center of hatchway. Load is constant on motor but counterweight is increased 720 lb. over that in Figs. 1 and 2. Figs. 5 and 6—Compensating cables connected to car and counterweight. Counterweight is reduced 720 lb., but compensating-cable weight is the same as in Figs. 3 and 4. Figs. 7 and 8—Compensating cable runs from car to counterweight. Weight of compensating cables and counterweight each reduced 720 lb. under that for the arrangement in Figs. 3 and 4, and full load on the motor is constant at 1,500 pounds.

steel or iron ropes. These weigh approximately 0.6 lb. per running foot, hence, if the total travel is assumed to be 200 ft., the weight of unbalanced rope would be 720 lb. Turning to Fig. 1, it is seen that this will add a load of 720 lb. on the motor at the first landing and subtract a similar amount at the top, Fig. 2. In Fig. 1, on the car side of the sheave the load is 2,500 + 4,000 + 720 = 7,220 lb., and the load on the counterweight side 5,000 lb., or a difference of 7,220 — 5,000 = 2,220 lb. When the car is at the top of the hatchway, as in Fig. 2, the weight on the car side of the sheave is 2,500 + 4,000 = 6,500 lb., where on the counterweight side the load is 5,000 + 720 = 5,720 lb., a difference of 6,500 — 5,720 = 780 lb. Thus a total variation in load of 2,220 — 780 = 1,440 lb. will be imposed on the motor. Referring to the car and load specifications, the net load on the motor, neglecting the ropes, was 1,500 lb. when hoisting the maximum load.

Taking up the first method of compensation, to determine the weight of the compensating ropes and the additional counterweight required to keep the load on the motor constant at 1,500 lb. when the car is fully loaded, as shown in Figs. 3 and 4. Referring to Fig. 3, it is seen that since one end of the compensating ropes is attached to a point midway up the shaft, their weight will have no effect on the motor when the car is at the bottom of the hatchway. Therefore the counterweight will be made up of three items; namely, weight of the car, 40 per cent of rated load and weight of the cables, or 4,000 + 1,000 + 720 = 5,720 lb. The weight of the car, load and cables with the car at the bottom landing is 7,220 lb., therefore the motor load is 7,220 — 5,720 = 1,500 lb.

When the car is at the top floor, the load on the car side of the sheave is the weight of the car and load and equals 6,500 lb. On the counterweight side the load is the weight of the counterweight plus the weight of the cables, or 5,720 + 720 = 6,440 lb.; consequently the load on the motor is only 6,500 — 6,440 = 60 lb. If the load were taken off the car at the top floor, the weight of the car (4,000 lb.) would be counterweighted by a weight of 6,440 lb. Therefore, for the motor to lower the car it would have to lift a load at starting of 6,440 — 4,000 = 2,440 lb. instead of 1,500 lb. if the weight of the hoisting cables were properly compensated. To maintain the load on the motor at 1,500 lb. will require attaching to the car compensating cables equal to 1,500 — 60 = 1,440 lb. In other words, the total weight of effective compensating ropes must be equal to twice the weight of the hoisting ropes included between the limits of travel.

Take the case of two separate sets of compensating ropes attached to the car and counterweighted as shown in Figs. 5 and 6. With the car at the bottom of the hoistway and the counterweight made equal to the weight of the car and 40 per cent of the rated load, the load on the motor when compensating ropes are not used is 7,220 — 5,000 = 2,220 lb. To reduce this load to 1,500 lb. will require compensating ropes attached to the counterweight, weighing 2,220 — 1,500 = 720 lb. When the car is at the top landing, the weight of the hoisting cables has been transferred to the counterweight, so that the load on the car side of the sheave is 6,500 lb. and on the counterweight side 5,000 + 720 = 5,720 lb., so that without compensating ropes on the car the load on the motor would be 6,500 — 5,720 = 780 lb. If the load is to be maintained at 1,500 lb., then the car compensating rope will weigh 1,500 — 780 = 720 lb. This shows that the same weight of compensating rope has to be used in either Figs. 3 and 4 or 5 and 6, but that in the latter case the counterweight can be reduced 720 lb.

Figs. 7 and 8 show a direct car-to-counterweight compensation. With this scheme the weight of the compensating cables is transferred to the counterweight when the car is at the bottom landing and to the car when the counterweight is at the bottom of the hoistway. In Fig. 7 the car, load and cables weigh 7,220 lb. and the counterweight 5,000 lb., or a difference of 7,220 — 5,000 = 2,220 lb. To reduce this difference to 1,500 lb. will require a compensating cable attached to the counterweight of 2,200 — 1,500 = 720 lb., which is the weight of the hoisting cable between the limit of travel. When the car is at the top of the hoistway, 720 lb. of the hoisting cables have been transferred to the counterweights and an equal weight of compensating cable to the car, so that the load on the motor is still 1,500 lb. This shows that the counterweight is not only at a minimum value of 5,000 lb., but the weight of compensating cables is one-half that required with either of the other two methods. A brief inspection of these three methods of hoisting-rope compensation, as shown by the foregoing discussion, will bring out the following points:

A. Method 1 requires the same weight of ropes as method 2, but additional counterweight, equal in weight to the hoisting rope, must be provided. However, an advantage of this method lies in the fact that it can be used in practically any installation, while the others may be eliminated on account of local conditions.

B. In method 2 space must be left for the second set of compensating ropes which again depends upon local conditions. The advantage of this method is that the counterweight compensating ropes assist the counterweight which may be held down to the minimum of 5,000 lb. This saving of 720 lb. weight may offset the increased cost due to dividing the cables.

C. Another factor that affects the design of the sheaves and particularly their bearings, is the total weight that will be suspended. In case 1 this will be 14,380 lb., while in case 2 it will be only 12,940, which shows a reduction of 10 per cent.

D. If the compensating ropes are attached to the car and counterweight as in case 3, they will transfer their weight in the same way as the hoisting ropes do. Hence, as shown by the calculations, only one-half the weight of compensating ropes of cases 1 and 2 will be required. At the same time the counterweight is kept at 5,000 lb. while the weight on the sheaves is 12,940 as in case 2.

Thus it is seen that the third method is the best from the viewpoint of weight that must be handled. As far as accuracy of compensation throughout the travel is concerned, there is little choice between the three systems provided that they are all well designed. Sometimes it is impossible to apply the third method, as for instance if the counterweights are hung in a separate well and interference with other machines prevents the carrying across of compensating ropes. Another factor that is of importance in high-speed equipments is the elimination of noise. It is practically impossible to get noiseless operation with chains above 500 ft. per minute. For this reason wire ropes are used in the application of the third method, even though the initial cost is increased.

EDITORIALS

F. R. LOW, EDITOR

Importance of Expression

IT CANNOT be too strongly impressed upon the young engineer—and under this name is grouped all power-plant employees and employees in designing engineers' offices—that not only is it essential that he acquire by study and experience all possible knowledge pertaining to the technical side of his work, but that it is just as necessary that he acquire by study and by reading that general knowledge of expression and composition that will enable him, when necessary, to present his views with force and conviction.

Frequently, an engineer is called upon to make a report on the present condition of a plant or upon a proposed change or new installation. Large sums of money may be involved, and procedures for years to come may depend on this report. It is necessary, therefore, that before making such a report the engineer make an exhaustive study of the entire situation. After this study comes, first, the analysis in his own mind of all the data that have been collected, and second, a review of all the points that have any bearing on the subject. Needless material which, if included, would weaken the remainder, must be eliminated. Voluminous detail must be condensed, and lastly, yet most important, the essential facts must be arranged in the proper sequence of their relations to the main point in question and to each other. It is here that the lack or the possession of that general training to which reference has been made will assert itself.

Instances are known where proposed work has been first suggested and reported upon after a fashion by employees of a power plant, but somehow the plans were never adopted, since the report did not carry the conviction or possess the force required to prove the desirability of the work being carried out. Then at some later time an outside engineer was called in to act in the capacity of expert and to make a report on the same matter. This expert would gather all the data from the power-plant employees, get their views on the points involved, receive their suggestions, then make out his report, which report was accepted and the engineer given the authority to go ahead with the work. The employee engineer naturally asks himself why not in his case and why in the case of the outside expert. The two propositions were almost identical, and the two reports agreed throughout on the major points. The reason lay in the manner of presenting the facts. Figures were submitted showing just what outlay would be required and also what profits or reduction in cost of power would result. The one could be therefore quickly balanced against the other. Every vital point that could be raised was covered by the report, and there was an answer to every important question that could be asked. Not only that, but the report as a whole was a finished piece of English composition, correct and complete.

Someone once said or wrote that "engineers as a class generally have something to say but do not know how to say it." Perhaps there is much truth in these words. Just as there are many men who, while they have complete knowledge of a subject, are utterly incapable of teaching that subject to others, so there are many who are unable to write convincingly about a subject or make out a proper report on a situation. In the latter case, however, it is not difficult for the young engineer by reading and practice to develop his powers of expression so that he will no longer be handicapped.

The Sesqui-Centennial

FEW realize that in one of the parlors of the Bellevue-Stratford in Philadelphia a large staff is busily engaged daily, under the direction of Col. John Price Jackson, in formulating plans and organizing what it is expected will be the greatest of expositions—the Sesqui-Centennial, to be held in that city in 1926 to commemorate the one hundred and fiftieth anniversary of the Declaration of Independence and to portray the progress of the World, particularly during the fifty years since the Centennial Exhibition of 1876.

The project has already received the official indorsement of President Harding and of Congress, as well as the legislatures of several states, which have authorized suitable appropriations for state buildings. The City Council has pledged five million dollars and over a million has thus far been privately subscribed. This is merely a start and adequate funds are assured as the work progresses.

In selecting Fairmont Park, embracing the old Centennial Fair Grounds, the Committee showed excellent judgment, not only because of the historical associations and its unsurpassed natural beauty, but on account of its accessibility to the heart of the city which will greatly facilitate handling the crowds and have a material influence on the attendance.

Unlike the San Francisco exposition in 1915, which took place just after Europe had become engulfed in the War, the Sesqui-Centennial will open at a time when the efforts of mankind are directed toward industrial development and the promotion of international trade. Therefore European participation is assured. Moreover, it will follow the British Empire Exposition, and many British exhibitors will doubtless find it convenient to ship over their exhibits.

Progress in applied science and industrial arts will occupy a major part of the exhibition, and it is also proposed to devote considerable attention to industrial relations and business economics. Inasmuch as power is fundamental to practically all industry, excellent opportunity will be afforded to illustrate its relation to the industrial growth of the country and to show how the ratio of horsepower to manpower has steadily increased. To the relatively few that will have been privileged to visit both the Centennial and the Sesqui-Centennial, the advance in the art of generating, transmitting and applying power will appear phenomenal. What more striking contrast could there be than be-

tween the one thousand four hundred-horsepower Corliss engine, which was one of the outstanding features of the earlier exhibition, and the modern turbine of forty times that capacity in practically the same floor space. Fifty years ago electricity was in its infancy; now it is indispensable to the comforts of society as well as to transportation and communication. Coincident with the ever-increasing power demand have come economies in generation and utilization that are important factors in conserving the nation's resources.

A feature of the Centennial was the tests and standards established—notably the boiler horsepower rating. Progress has rendered many of these obsolete, but the Engineering Congress which will form part of the Sesqui-Centennial might well be made the occasion of initiating other standards, especially in matters of international usage.

Although the affair is nearly three years off, the task is stupendous. The committee has been actively engaged for over a year, but it cannot do all. Popular appreciation of what the Exposition will mean to industry must be awakened; and the sooner the better.

The Vacuum Tube as Applied to the Power Plant

IN RECTIFYING alternating current, or in other words transforming it to direct current, the mercury arc rectifier, one member of the vacuum-tube family, has been in commercial use for about fifteen years. At present it is successfully competing with rotary machinery in furnishing current for series arc lighting circuits and for charging storage batteries.

While discussing future developments at the recent convention of the N.E.L.A., the manager of the Lighting Department of the General Electric Company, C. W. Stone, drew attention to the fact that various forms of vacuum tubes had been built to transform from one frequency to another, single-phase to three-phase, direct current to alternating of any phase, voltage, frequency, etc. The elements of such equipment are now in commercial operation. Experiments are going forward toward placing these on a commercial basis.

It is not likely that vacuum tubes will become as important an adjunct of the power house as the amplifier now is in a wireless-telephone set. On the other hand, laboratory work in some instances is rapidly succeeded by power-plant practice. A great field awaits the production of such apparatus suitable to commercial requirements.

Sixty-cycle current makes possible a two-pole turbo-generator, operating at 3,600 revolutions per minute, the cheapest type to construct at that speed. For a waterwheel running at 120 revolutions per minute, however, a sixty-cycle generator must have sixty poles, and therefore cost several times as much as an equivalent two-pole generator. In many cases low-frequency transmission lines are designed to suit low-speed waterwheel-driven generators; the saving in cost of generators for lower frequencies and hence of fewer poles, makes this imperative. By using a suitable frequency transforming unit, a waterwheel generator at 120 revolutions per minute could be built with two poles, at two cycles per second and operated on the sixty-cycle line in multiple with a two-pole turbo-generator.

A step-up gear between waterwheel and generator would answer the same purpose; so would a frequency changer set. The former plan sometimes pays at the present time, notably in Europe. The vacuum tube in any capacity, will meet competition.

Transmission lines could carry larger amounts of direct-than alternating-current power at equal voltage. Vacuum-tube transformation would permit the generator to be built at a suitable frequency voltage and phase winding before being stepped up to requirements of transmission power. The modern large static power transformer represents one of the most efficient, reliable and easily maintained power elements so far developed. The vacuum tube in its present state does not appear as an equal of the static transformer in these respects. In must be remembered, however, that there will be great economic incentive to increase the capacities of transmission lines. It is not likely, with these savings in view, that a transforming unit will be required to equal a static transformer in operating efficiency and effectiveness.

In general, existing machinery may be applied to do any of the things for which vacuum tubes are adapted. Their success, therefore, will depend largely on commercial costs, efficiency and reliability. Special or local conditions may justify a few installations of such apparatus before general adoption is warranted.

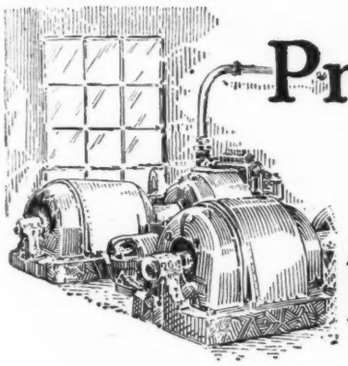
Results obtained from such special or experimental installations will indicate to better advantage what changes vacuum tubes are likely to produce in power-plant machinery.

The Unexpected Difficulty

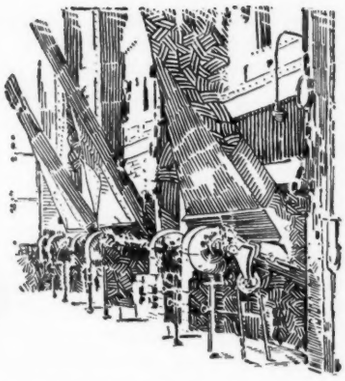
WITH every new development problems arise that even a good engineer might easily overlook in making a preliminary study. An example is found in the use of bleeder heaters to heat the feed water by means of steam extracted from the main unit. While either an open or a closed heater may be used for this work, a certain unexpected difficulty arises in the case of the open heater because it contains a large mass of stored water at a temperature but little below that of the bled steam.

No harm can be seen in this until attention is called to the condition that might arise if the load were suddenly removed from the turbine. In such an event, the steam pressure at the extraction point would fall below that corresponding to the temperature of the water in the heater. This would immediately result in the evolution of steam from the water at a rate depending on the reduction in pressure, the action corresponding exactly to that in a steam accumulator. If this steam were allowed to flow back into the turbine through the bleeder connection, it might, under certain conditions, cause the overspeeding of the turbine. To prevent such an occurrence, open heaters, where used as bleeder heaters, must be provided with valves that will close automatically if the steam flow starts to reverse. With the closed heaters ordinarily used, trouble from this source is avoided by draining off the bleeder condensate as fast as it forms.

While the particular difficulty just used as an illustration was probably foreseen by early designers of bleeder heaters, there is always the possibility, not merely of overlooking the possible occurrence of some well-known phenomenon, but of running into difficulties that could hardly have been predicted. This fact prevents the final stamp of success from being placed upon any new development, however attractive on paper, until it has stood the test of service.



Practical Ideas *from* Practical Men



Grounding the Neutral Caused Many Fatal Accidents in Holland

With reference to grounding the neutral, a recent official investigation in Holland brought out that the low-voltage accidents increase in almost direct proportion to the growth of the systems that supply light and power by means of a three-phase circuit with grounded neutral, having voltages of 380 to 220 and 220 to 127 respectively, intended for power and lighting. Many

ACCIDENTS ON LIGHT AND POWER CIRCUITS

Year	300 Volts and Less From Phase to Ground Injured	300 Volts and Less From Phase to Ground Killed	Above 300 Volts From Phase to Ground Injured	Above 300 Volts From Phase to Ground Killed	Totals
1909	8	..	..	2	10
1910	21	..	..	1	22
1911	18	..	..	..	18
1912	13	..	..	..	13
1913	27	3	4	..	34
1914	25	4	2	..	31
1915	36	5	..	2	43
1916	51	4	1	..	56
1917	56	3	1	..	60
1918	51	5	6	1	63
1919	62	2	20	5	89
1920	68	8	20	5	101
1921	89	18	27	1	135

of the fatal accidents are directly attributable to grounding the neutral and occur chiefly in industrial plants. The table shows the rate of increase of electrical accidents from 1909 to 1921 and indicates that accidents due to high distribution voltages are exceptions and not the rule. H. WIELAND LOS.

Schoonhoven, Holland.

Revolving Work Advantageous in Drilling Accurately

To drill a small hole with considerable depth so that the hole will be in line with the face of the work, as on a round bar, or to terminate the hole on the opposite

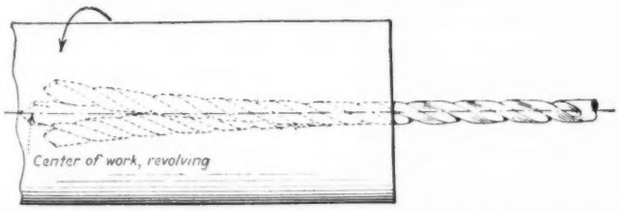


FIG. 1—WHEN THE WORK IS REVOLVED THE END OF THE DRILL OFFERS RESISTANCE TO BEING SWUNG IN A CIRCULAR PATH

side of the work at a point opposite the start, is required in some machine-shop work.

After considerable experimenting in one machine shop, the most dependable results are obtained in this deep drilling through holding the drill stationary and revolving the work. With this means holes 15 in. deep are put in cylindrical bars with drills slightly less than $\frac{3}{16}$ in. in diameter, and the drilling terminates closely in line with the start. As is illustrated in Fig. 1, the reason that this gives better results is attributed to the resistance that the end of the drill offers to being swung in a circular path about its axis.

The tendency for the drill point is to seek its normal

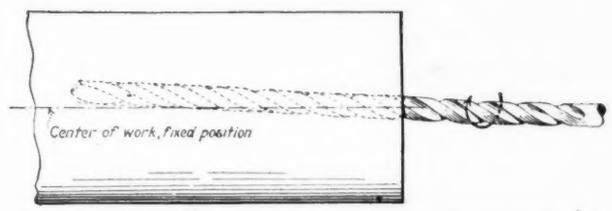


FIG. 2—WHEN THE WORK IS HELD STATIONARY THE DRILL TENDS TO CUT OFF CENTER

center, and this tendency is apparently enough to cause it to cut straight. When the work is held and the drill revolved, the drill would seek some offside course and the terminal of the hole would be far off center, as illustrated in Fig. 2. G. S. LUERS.

Washington, D. C.

Suggested Rotary Heat Engine Requires No Packing Glands

This form of heat engine is not necessarily practicable, but is presented to the readers of *Power* for discussion and suggestions.

Leaks, whether actual or possible, are disadvantageous in a heat engine employing mercury, ammonia, ether or other costly working fluid. The single unit of boiler, turbine and condenser, all contained within a sealed rotating chamber as in the Fig. 1, is not subject to leaks in any degree approaching those of the usual type of turbine containing shaft glands. Appreciable heat saving is made possible by using fluids like the aforementioned in connection with condensers of steam units operating on the binary vapor cycle, for the purpose of utilizing heat otherwise wasted in the cooling water.

The expansions occurring in a binary vapor cycle are illustrated in Fig. 2. A steam engine would expand along the lines *AC* to somewhere near zero pressure. The amount of work obtained in the lower portion of this curve from *C* to zero would not pay commercially for the added cost of the larger cylinder necessary to utilize such expansion.

This heat, however, may be reclaimed to some extent by exhausting at *B* into a closed heater, so that a more volatile liquid, such as ether or ammonia, may absorb

this heat. The vapor produced by the heat of exhaust steam will have a higher pressure and smaller volume, as shown by curve *DEF*. A smaller and commercially economical cylinder may then be utilized for the secondary vapor, expanding much nearer to absolute zero pressure. The secondary vapor, of course, may receive heat at the exhaust *C*, instead of at *B*, if commercial savings are better than would be obtained as first described.

Some refrigerating machines maintain a leak-proof cycle for their vapor by means of a rotary outer element integral and unpierced by the inner element. The latter is held relatively stationary by making the lower part heavy, so as to prevent rotation. This process, it seemed to me, of supplying kinetic energy to a mechanism containing vapor inclosed in a leak-proof casing and extracting thermal energy, could be reversed. The ordinary process of a heat engine, that of supplying thermal energy and extracting kinetic energy, then might be attained. The cycle still being leak-proof in this manner, the cost due to leakage of expensive vapors as in a binary vapor cycle would be eliminated. The outcome of this thought was an application for a patent on the heat engine shown in the enclosed diagrammatic sketch, Fig. 1. The thermodynamic cycle is that of the ordinary external-combustion engine of the turbine type. The basis of the idea lies solely in a different mechanical construction.

The whole mechanism, as shown, is suspended from suitable bearings in which it is free to revolve. A rigid shaft passing the length of the machine serves for strengthening and for other purposes which will be mentioned later. Surrounding this shaft are the three principal elements of heat engines of this cycle—boiler, turbine and condenser. The casings of these three elements are rigidly attached to each other and revolve together. The inner element of the turbine is suspended from the shaft by suitable bearings and is held stationary by a weight, as shown in the sketch, or relatively so, by means of electric lines of force.

In this way the general order of things is reversed, the outer element of the turbine becoming the rotor and

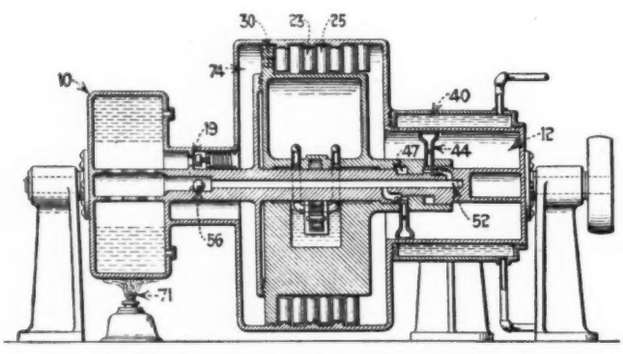


FIG. 1—PROPOSED HEAT ENGINE CONTAINED IN ROTATING SEALED CHAMBER

the inner element the stator, making it unnecessary to pierce the turbine casing. The condensate is returned from the condenser to the boiler through the hollow shaft by means of a pump or vapor jet, (not shown in sketch) or by means of centrifugal force. From the diagram, Fig. 1, the cycle is as follows: Heat (71) is applied to a rotary boiler (10) causing the liquid to vaporize and form pressure. The vapor pressure opens the loader valve (19) allowing the vapor to pass to the vapor chest (74). Thence the vapor passes through the nozzles (30) and alternately through the moving blades (23), causing the rotation, and through the stationary blades (25), discharging finally into the condenser (12), where it is condensed by cooling water (40). The condensed vapor is picked up by scoops (44) held by the stator and returned by a pump (47) through the hollow shaft (52) and the check valve (56) to the boiler, completing the leak-proof cycle.

The application of this machine to the vapor cycle

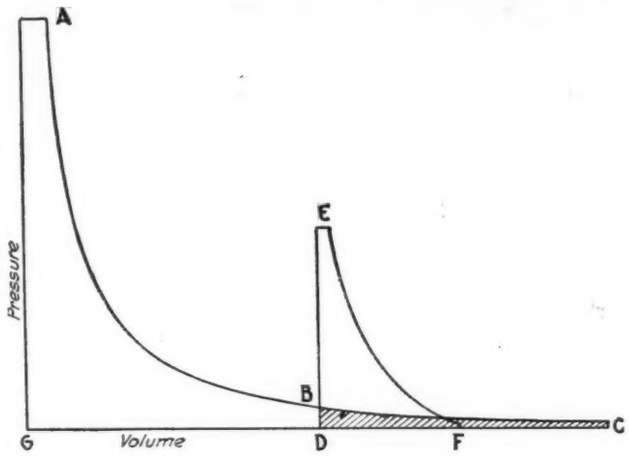


FIG. 2—SECONDARY VAPOR EXPANDS AT HIGHER PRESSURE AND LESS VOLUME

must be considered for two cases: First, where the vapor used, other than steam, has a higher range of temperature for working pressures than steam; second, where the reverse condition is true.

In the first case the heat of the fuel would be applied to the rotary boiler, vaporizing the liquid which would be condensed by cooling water, turning this to steam to be used in an engine or turbine. In the second case heat of the fuel would be applied to water in an ordinary boiler, to change it to steam. After using the steam in an engine, the exhaust would be condensed by circulating around the rotary boiler, vaporizing the contained liquid, which would in turn be condensed by cooling water.

Generally speaking, gains in thermodynamic efficiency could be obtained in both these cases, but particularly, I believe in the first case.

The mechanical difficulties in making such a machine practical, would be very great—might, indeed, render its application impossible. Boiler tubes, for instance, probably could not be used in a rotary boiler, some sort of fin arrangement being necessary to obtain the proper heat transfer. On the other hand, the fine separation in a rotary boiler would be favorable to high rates of evaporation.

It is interesting to note that most vapors besides steam would require a lesser blade speed than steam for maximum efficiency. The condenser construction would probably be somewhat similar to that of the boiler. Returning the condensate to the boiler seems to present no unusual problem. The greatest difficulties to surmount of all, it seems to me, would be those produced by heat expansion in such a rigidly constructed machine, and that of lubrication. A lubricant mixed with the working vapor might be possible. I have tried to do no more in the sketch than to indicate that a self-contained lubrication system would be necessary.

Nacozari, Mexico. J. C. TEN EYCK, JR.

Comments from Readers

Removal of Soluble Sludge

It is rather unfortunate that, in reviewing the Prime Movers' Report of the National Electric Light Association, in the June 12 issue, particularly that part of it dealing with lubrication, the reviewer dealt with the abstract of the report instead of the report as given on pages 318 to 325 inclusive, Part B of the full report.

I refer especially to the statement which, in relation to soluble sludge, says: "No equipment now commercially available will remove it from the oil." This statement was likely written by the committee in the early days of its investigation. The continuous "bypass-batch" system will remove not only the insoluble sludge, but also soluble sludge. The committee itself says so on page 323, Part B of the Report, as follows: "Since soluble sludge only appears when the oil has been cooled considerably below operating temperature, it can only be removed by a separate batch treatment."

The committee further confirms this in the final paragraph of its report on this subject, page 325, Part B: "It is the committee's consensus of opinion that if a continuous bypass filtration or purification process which will fulfill all practical requirements could be designed, it would be the ideal system, instead of having to resort to a combination of continuous bypass and batch systems."

Ft. Wayne, Ind. C. H. BROMLEY,
Manager, The Richardson Phenix Div.,
S. F. Bowser & Co.

Gas-Engine Indicator Diagrams

Sufficient data were not given in connection with the diagram from a 48x60-in. blast-furnace gas engine submitted by A. Fritz in *Power*, May 22, to allow any certain conclusions to be reached as to the cause of the peculiarities. It is unquestionably not a normal diagram from this type of engine, whether it is operated on the constant-mixture or the constant-compression type, although indications are that it is from the latter. To arrive at the proper cause for its appearance, several things should be known, such as the spring scale, the speed, the load of the engines from minimum to maximum, and other such factors as determine the shape of the diagram.

Irrespective of these factors, however, it is decidedly not a typical blast-furnace gas-engine diagram, as changes in load from the range of no load to full load, with the valve gear properly set and ignition occurring at the proper time, should produce diagrams that are, at least, symmetrical in shape, though varying in total area.

In this connection it would be well to have the points of the valve openings and the ignition that prevailed when the diagram was taken, as these are now accepted to be standard for this class of service within well-defined limits, although it is true that considerable variation can take place in the valve setting before the effect even becomes noticeable in the indicator diagram.

At first inspection it would seem that the trouble was not in the actual working conditions in the cylinder, but rather due to indicator piston sticking. The writer has never found conditions in which the tops of diagrams appear as they do in this instance, that do not finally prove to be the result of some condition of this kind. The most objectionable features of the diagrams are the conditions of the line below what is assumed to be the atmospheric. That the exhaust valve is late in its opening, as shown by the end of the diagram, will account for the shape of the lower line. Just why, with a variable load and several distinct changes in the power end of the diagram, or that above the atmospheric line, there is but a single line below the atmospheric is inexplainable. The writer has never been able to retrace these lines, even with a comparatively uniform load, since, with every change in the power diagram a corresponding change will occur in the suction part of the diagram. This is not as noticeable in the case of a constant-compression type of engine as it is in the constant-mixture type, owing to the fact that the total volume of mixture in the cylinder and the consequent suction pressure on the inlet stroke do not vary over such a wide range.

However, the effective heat units per cubic foot of mixture in the cylinder at different loads are reduced and this accounts for the lack of burning that occurs at the lower loads in the constant-compression type of engine and may have had some bearing on the smaller diagrams shown by Mr. Fritz. But in indicating engines, even of this type, such diagrams have never been obtained by the writer. A. C. DANKS,

Cleveland, Ohio.

The Influence of Radiant Heat

Having read with general endorsement the article "The Influence of Radiant Heat on Furnace Design," by Prof. A. G. Christie, in the May 29 issue, I would draw attention to the matter of the transparency of water to heat waves. In the northern countries in winter there is much trouble from ice that forms on the bottom of shallow and rapid-moving streams. This ice forms on clear nights only, and never under bridges or other caves.

Regardless of atmospheric temperature it never forms when the sky is overcast. It does form under water that is somewhat above freezing temperature. Professor Barnes, of McGill University, made exhaustive study of the phenomenon. It is related that he spent many nights on the banks of the St. Lawrence taking and noting temperatures. He reached the conclusion that heat radiation was the cause.

This radiation must be going on at all times. By the law of exchange there is compensation except on a cold clear night; on such an occasion the loss by radiation is greater than all sources of compensation.

With an overcast sky or other cover there is heat

radiation which is reflected back, thus passing twice through the intervening water. Research would probably show a maximum and minimum transparency of water, depending on the temperature of radiating body, and consequently the length of wave.

While this shows an exception to the rule, it does not detract in the least from the conclusions of Professor Christie, for in general water is an absorbent of heat.

On page 850 of the May 29 issue, in speaking of gas pressure it is stated that "this pressure increases with an increase of temperature, weight or molecular weight of the gas." I take this to mean that oxygen (O_2) gas would have sixteen times the pressure of hydrogen (H_2) gas at the same temperature and gram molecules.

Avagadro says all gases at the same volume, temperature and pressure have the same number of atoms or molecules; that is, one gram molecule of oxygen would have the same volume, temperature and pressure as one gram molecule of hydrogen. At the same time it would weigh sixteen times as much, the respective weights being 32 and 2 grams. E. C. WESCOTT.

Sacramento, Calif.

Tubes, Steam Domes and Dry Pipes

I was much interested in Mr. Wakeman's article on "Tubes, Steam Domes and Dry Pipes" in the April 17 issue, and more especially in the closing paragraph and its accompanying illustration, Fig. 3, as I have had occasion to make a large number of inspections of the so-called dry pipes of this type.

One prominent boiler manufacturer disclaims, for this construction, any ability to remove moisture, and states that its function is solely to collect the steam from the entire space of the drum through which it extends, although he points out that in some cases it is used to restrict the flow and avoid priming.

Obviously, since the outlet holes are just under the top shell of the drum, the greater part of the heavy surges that may occur in the drum during high ratings will not reach these holes, and it will thus, in a way, act to prevent this water from getting into the line; but it has been my experience that in many instances water leaves the boiler under conditions that can in no way be charged to priming. In fact, one plant in which this occurred, was particular to keep from concentration of boiler-feed water to a point that precluded the possibility of this trouble, but it had been known to occur and was traced directly to load changes and the resultant demand for steam. Furthermore, when the drain holes at the bottom of the pipe become plugged, the water, resulting from lighter loads, will collect, forming a pocket along the entire length of the pipe, all of which will be picked up when the velocity is increased by sudden load demands and carried into the superheater or other equipment farther down the line.

This fact is also assisted by the sharp change in direction that the steam takes at high velocities when entering this pipe, and in the presence of no baffle the water falls to the bottom of the pipe. As the pressure in the boiler drum is slightly higher than that in the dry pipe, the drainage to the boiler cannot be affected, thus causing additional building up until the velocity of the outgoing steam picks it up, often possibly in slugs that are easily seen on the recording chart of a thermometer that may be connected to the superheaters or steam lines. I have in mind one installation so equipped, in which an expensive turbine repair was caused by water carried over in this manner, and the recorders showed conclusively that it was the result of sudden load changes and not due, as often supposed, to the increased concentration and subsequent priming.

While it is usually supposed that no appreciable drop in pressure occurs in such a pipe, this is not correct, for as much as 6 lb. has been found under normal ratings, and it may be much higher under increased ratings. This pressure drop is not all due to the variation in the total area of the number of holes in the dry pipe as compared to that of the outlet connection on the boiler drum, but to the losses through the many small orifices that the holes constitute.

It is not unusual to find a large percentage of these openings plugged if certain systems of mechanical feedwater treatment are used, and as much as 30 per cent of the entire outlet capacity has been found plugged after a comparatively short period of operation.

As Mr. Wakeman points out, there is nothing in the pipe to remove the moisture and the one other consideration of vital importance is that the proper velocity does not prevail in the pipe to have the moisture removed, regardless of what was in it for this purpose, which accounts for the failure of any apparatus to remove moisture that does not take this fact into consideration.

Unquestionably, the proper place to remove the moisture from steam is in the boiler drum, where the velocities can be kept down to a point at which the actual separation can be made to take place. The area required to effect this separation will depend on the actual operating conditions such as the total steam to be passed, the nature of the solids to be removed, and other similar considerations. The problem is much the same as removing moisture and its accompanying solids from any gas such as is encountered in the cleaning of air for turbine ventilation, gas for the use in engines, etc., and experience here has shown that, until the velocity has been dropped to a certain point, in each case the cleaning was not effective.

This same condition is true of steam and accounts for the inability to get this material out after the steam has once left the drum and obtains the velocity of 6,000 to 10,000 ft. per minute, or even higher in the lines, since, when any particles of moisture being carried along with the steam at such rates of flow, meet with the baffle of any description, the effect is not to arrest them, but to break them up into such sizes that they will remain in suspension and be carried farther along the line. The importance of dry steam, while not being underestimated, is often misconstrued and considered as that carrying anywhere from 1½ to 3 per cent of moisture. It should also be remembered that each 1 per cent of moisture leaving a boiler on which a superheater is installed, means a loss of approximately 14 deg. in the available superheat.

It is usually thought that once superheaters are installed the trouble with water and all the equipment such as turbines, engines, etc., will cease, but it is now an accepted fact that water can and is often carried in slugs as the result of sudden load changes from the boiler drum directly into the superheaters through long lines and into the turbine blading, etc. I have had experience of this kind that finally led to the replacing of a turbine shaft. My attention was called to one rather interesting incident in which the operators maintained that, owing to possible uneven circu-

lation conditions, the water level in the boiler drum was such, at one end only, that the dry pipe was actually partly submerged and was found to be responsible for the high percentage of moisture and the frequent slugs that were being carried over into the equipment.

Whether or not this was actually the case, I do not know, but it was evident from operating conditions in this plant that water in large amounts was leaving the boiler through the so-called dry pipe; and with operating conditions similar, this condition will continue until a construction is used in which the velocity is kept down to a point at which this separation can take place.

Cleveland, Ohio. A. C. DANKS.

What Design of Furnace Is Best for Burning Mill Refuse?

Referring to the request of R. B. McQuiddy, in the issue of May 8 for information covering the design of a furnace for burning wood-mill refuse, because of the great variation in wood-refuse fuel as found in the various sections of the country, each particular job presents a special problem. There are, however, a few fundamental principles and facts that are common to all.

Wood refuse contains a large percentage of volatile and from 25 to 60 per cent of moisture. Proper combustion therefore requires a large furnace volume to consume the volatile and an arrangement of reflecting brickwork to keep up the furnace temperature. The general practice is to pass the larger pieces of refuse through a hog in order to facilitate feeding and to assure better furnace conditions.

The majority of wood-refuse furnaces are of the Dutch-oven type with flat or slightly sloping grates and with a more or less continuous stream of fuel entering through a hole in the top to pile up in a cone on the grates. The height of the arch and the shape of the grate should be such that the extreme edges of the grate will just be covered by the cone. The ideal width of the grate surface is about six feet, although many furnaces are made wider. For larger furnaces two cones can be placed crosswise of the furnace. If the furnace is too wide for one cone, a division wall should be used. This will serve to support the arch. The fuel hole should be about 12 in. toward the front from the center of the grate because the fuel has a tendency to travel with the gases toward the bridge wall.

In order to evaporate the large percentage of moisture usually found in wood refuse, furnace temperatures must be kept rather high. The design of the arch and the furnace throat determine the temperature. The usual height of the arch above the grate is from 5 to 7 ft., but this is dependent on the width of the furnace. A full sprung arch, because it more nearly approximates the profile of the fuel cone, is more suitable than the flat type. The arch should extend beyond the bridge wall preferably not less than 12 in. The area between the arch and the bridge wall, the furnace throat, should be from 6 to 14 sq.in. per 10 sq.ft. of boiler-heating surface, depending on fuel moisture, available draft and expected rating. The smaller the throat the higher the furnace temperature. In some instances it has been found advantageous to drop the rear end of the arch.

Most of the combustion takes place on the surface of the cone, and the necessary air should be available at this point. Excess air is as undesirable with wood refuse as with any other fuel. Some of the required air passes through the fuel bed, but by far the greater amount leaks through the furnace doors or passes in with the fuel through the top. In some plants it has been found desirable to eliminate most of the air entering through the top by means of a balanced trapdoor. The required air is then admitted through the furnace front, where it can be controlled. There is a special acid- and heat-resisting steel plate in commercial use which stands up rather well when used on these trapdoors. Because of the large amount of volatile in the fuel it is desirable to have an ample combustion chamber back of the bridge wall. A part of the finer fuel will be carried over into this space, and in order that this material may be consumed, it is good practice to admit some supplementary air into this space. The most convenient place for the admission of this air is through the bridge wall.

There are many different designs of grates in use. It is desirable to secure the greatest percentage of air space possible without objectionable riddling. In general the slots should be not wider than ½ in. and the bars should be small in order to better withstand the severe conditions imposed by this fuel. From 150 to 300 lb. of steam can be generated per square foot of grate area.

The ashpits should be deep in order to keep the grates from overheating. If sufficient water is available, it is desirable to carry the ashes from the pit in a trough or flume. Many plants have been equipped to keep the ashpits flooded so that all riddlings will be quenched and the grates kept cool.

It is possible to burn wood refuse in a properly designed furnace with not over 30 per cent excess air. This corresponds to about 16 per cent CO_2. The stack requirements are about the same as for an equal-sized coal-burning plant.

Fuel should never be blown into the furnace because of the excessive amount of air admitted. If the fuel is conveyed by air, a cyclone head should be used over the fuel hole in order that most of the air may be eliminated.

Tests made on thirty samples of wood refuse representative of the various parts of the country showed an average of 46 per cent moisture and 8,700 B.t.u. per pound of bone-dry fuel. The extremes of moisture content on the list were 66.8 and 22 per cent, while the extremes of heat value were 9,290 and 8,040 B.t.u. per pound of moisture free fuel. An average evaporation is 10,000 lb. from and at 212 deg. per unit of 200 cu.ft. of fuel averaging about 3,800 lb. in weight.

San Francisco, Calif. M. S. GEREND.

Drums and sheaves for elevators should be of the largest consistent diameters. Such diameters should never be less than 38 to 40 times the cable diameter. The grooves of drums and sheaves must be smooth and correct in size for the particular size of rope used. If multiple-grooved drums or sheaves are not grooved to identical diameters or if some of the grooves become worn, excessive wear to cables results. In drum machines it takes the form of unequal loading of cables working in pairs. The fault is exaggerated in traction machines. To illustrate, if one of the grooves of a traction sheave happens to be smaller in diameter than the adjacent grooves, a turn of the sheave will not wind an equal length of cable in the short-diameter groove as in the long-diameter grooves, and the cable must slip to keep up to its companion cables. An apparently insignificant difference in diameters may cause several inches cable slip during each car run.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Place for Introducing Boiler Compound

In operation of a water-tube boiler and open-exhaust steam feed-water heater, should a boiler compound be supplied at the heater or fed by a circulator connected in the feed line between the pump and the boiler?

E. M.

Both methods are practiced according to convenience, but where the feed-water ingredients are precipitated at the temperature attained in the heater, it is better to introduce the compound in the heater to prevent formation of scale in the suction pipe of the feed pump.

Insufficient Submergence for Air Lift

We have a 26-ft. well with 3-in. casing, from which our present water supply is obtained with a small reciprocating electric pump. Could not an air lift be employed for raising the water from this well to an open storage tank located about 35 ft. above the ground? The water stands about 12 ft. deep in the casing when the pump is at rest.

L. C. H.

The efficiency of operation of an air lift depends mainly on the ratio of the air-pipe submergence to the total lift, measured vertically from the foot of the air pipe to the level of the point of discharge. For efficient operation the percentage of submergence should be about 70 per cent. Without any allowance for drop of level of water in the well during pumping, the greatest submergence obtainable under the conditions stated would be 12 ft., and having a total lift of $26 + 35 =$ 61 ft., with submergence of only $\frac{12}{61}$ or less than 20 per cent of total lift, operation of an air lift could not be depended upon.

Standard of Comparison of Expansion Curve of Diagrams

What is the difference between the "pv = a constant" curve and the adiabatic curve, and to which is the expansion curve of a diagram from a steam engine compared?

W. H.

The curve known as "pv = a constant," is one that would be obtained by expansion or compression of a given volume of steam to any other volume and the product of pressure and corresponding volume is a constant quantity; that is, the volumes are inversely as the pressures, or the pressures are inversely as the volumes. Under good working conditions steam engines with tight valves and pistons give indicator diagrams whose expansion curves closely approach the "pv = constant" curve, and on that account it is generally used as a basis of comparison.

When dry saturated steam or a perfect gas is expanded without any gain or loss of heat excepting that which is converted into work, the expansion is said to be adiabatic and consequently the pressure after expansion is less than if the temperature had been maintained and the product of the final volume and pressure will be less than the product of the initial volume and pressure. In place of having pv = a constant, the equation for adiabatic expansion is pv^n = a constant, and in case of dry saturated steam the value of the exponent n is 1.1.

Power Absorbed by Dead Pulley on Lineshaft

What would be the method of computing the power loss caused by running dead pulleys on lineshafting?

G. R. P.

The power loss would result from windage or direct resistance to rotation caused by the atmosphere, and the greater friction of the shaft bearings due to the weight of a pulley. The wind resistance would depend on the form of the pulley arms, their size and the number of revolutions per minute.

With ordinary sizes and forms of pulley arms the power required for overcoming wind resistance is so small as to be inconsiderable. When two plain 10x14-in. fan blades are carried by opposite arms at a radial distance of 15 in. from the center of rotation to the longer side of the blade and rotated in free air at 400 r.p.m., the power absorbed is about one horsepower. Under other conditions the power absorbed depends on the size of blades, their distance from the center of rotation and on approximately the cube of the number of revolutions per minute From this it may be assumed that the windage of a 30-in. cast-iron pulley of ordinary form of arms and running at 400 r.p.m., would be considerably under one-tenth of one horsepower.

The absorption of power of shafting due to a dead pulley would be the same as that due to the same weight of shafting. The average coefficient of friction of iron or steel shafting in horizontal bearings is about 0.07 for ordinary oiling and about 0.043 for continuous oiling. Where d = the diameter of the journal in inches, the space passed over for one turn would be $\frac{d}{12} \times 3.1416 = 0.26d$ ft. hence the power absorbed by a journal bearing for w pounds weight of shaft or pulley, or tension of belts, where d is the diameter of journal in inches, n the number of turns per minute, and h the number of horsepower absorbed, would be,

$$h = \frac{0.07 \times w \times 0.26d \times n}{33{,}000} = \frac{w\,d\,n}{1{,}813{,}187}$$ for ordinary oiling

$$h = \frac{0.043 \times w \times 0.26d \times n}{33{,}000} = \frac{w\,d\,n}{2{,}951{,}699}$$ for continuous oiling.

Dry Air Pump

What is the principal duty of a dry air pump and why is it so called? G. A.

The exhaust of a steam engine, as discharged to a condenser, is a mechanical mixture of steam, water and gases, the gases consisting of those originally dissolved in the boiler-feed water and atmospheric air which leaks into those parts of the low-pressure cylinder, the exhaust connections and part of the condensing system in which a partial vacuum is maintained. These gases cannot be liquefied by the cooling action of the condenser and must be removed from it as gases, otherwise their accumulation results in building up of a back pressure considerably higher than the pressure of steam corresponding with the temperature. Pumps that are intended to clear a condenser only of water, or of water as well as gases and vapors, are called wet vacuum or wet air pumps, but a pump that is principally intended for separate removal of air and uncondensable gases and vapors is called a dry air pump and is so designated to distinguish it from a pump intended to handle the liquid condensate formed in the condenser.

Safety Valve on Superheaters

Should a safety valve be used on all superheaters; and when used, should the superheater safety valve be set to blow at a higher or a lower pressure than the safety valve on the main boiler? W. H.

A superheater always should be provided with one or more safety valves near the outlet. The discharge capacity of the superheater safety valve or valves may be included in determining the number and size of safety valves for the boiler, provided there are no intervening valves between the superheater safety valve and the boiler and the discharge capacity of the boiler safety valve or valves is at least 75 per cent of the total valve capacity required. When there is a stop valve between the boiler and superheater, the capacity of the superheater safety valve should be sufficient for relieving the maximum steam-generating capacity of the superheater in case the intervening stop valve were closed, with the superheater partly or wholly flooded.

The safety valve or valves on the superheater should be set to blow at two or three pounds less pressure per square inch than the safety valve on the boiler to prevent the superheater from becoming burnt out in case the demand for steam is not sufficient to insure circulation, when the boiler pressure is high enough to open the main safety valve.

Loss of Power from Belt Slippage

In the transmission of power by belts and pulleys why is it assumed that there is a loss of power equal to the percentage of belt slippage? W. L.

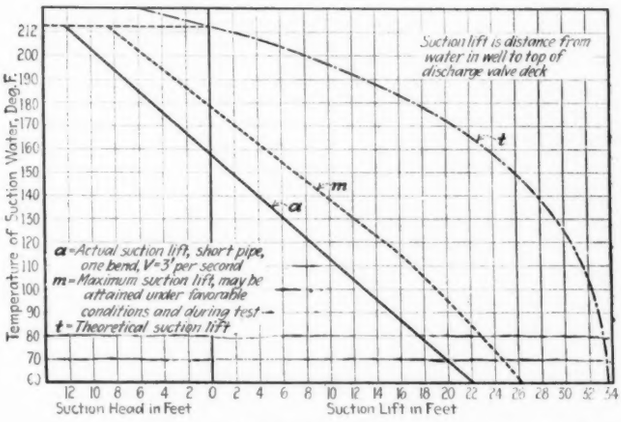
The number of foot-pounds of work delivered per minute by the driving pulley would be the peripheral speed, feet per minute, multiplied by the net resistance of the belt in pounds, taken as the difference of the tension of the driving side and slack side of the belt. Without any slippage the whole peripherial velocity of the driving pulley would be imparted to the belt and the foot-pounds of energy delivered to the belt would be equal to the energy absorbed from the pulley. In case of complete slippage the energy is entirely absorbed by friction between the belt and pulley as with a Prony brake, and no energy is transmitted to the belt because there is only belt tension without the element of velocity. The whole or part of the energy initially absorbed may thus be lost by slippage of the belt on either the driving or receiving pulley, and as the output of the driving pulley is to the energy available out of the receiving pulley directly as their actual peripheral speeds, the percentage loss of initial power is the same as the percentage of belt slippage.

Suction Lift at Various Temperatures

What are the theoretical and practical suction lifts for water at temperatures varying from 60 to 212 deg. F.? H. T.

The theoretical suction lift may be considered as the height to which water will stand in a suction pipe when the pressure due to the head, plus the pressure of vapor liberated from the column of water due to its temperature, is equal to the pressure of the atmosphere. Thus for vaporization at 160 deg. F., as given in steam tables, the absolute pressure would be 4.7 lb. per sq.in., and for the atmospheric pressure 14.7 lb. per sq.in., the pressure due to the head could be 14.7 — 4.7 = 10 lb. per sq.in., and allowing 0.424 lb. per foot of head at this temperature, would make the theoretical lift 10 ÷ 0.424 = 23.6 feet.

The suction head obtainable in pumping is less than



THEORETICAL, MAXIMUM AND ACTUAL SUCTION LIFTS FOR VARIOUS TEMPERATURES

the theoretical lift since, in addition to supporting the head of water and pressure of vapor, the effective pressure of the atmosphere is reduced in supplying pressure required for the velocity head, entrance head, head lost in suction-pipe friction, bends, losses through valves and inertia of water column and in overcoming the pressure of air liberated from the water or finding its way through joints.

The illustration shows the suction heads and lifts with water at various temperatures, 60 to 212 deg. F. Curve *t* is the theoretical suction lift; curve *m* is the maximum suction head or suction lift under favorable conditions, such as may obtain during a test; and curve *a* is the actual suction head or suction lift attainable with a tight piston pump and connections and short pipe with one bend and suction water velocity of 3 ft. per second. For a long suction pipe, high velocity, more bends or other obstructions such as a foot valve, strainer or condenser, the losses of head must be added to the required suction head or deducted from the obtainable suction lift indicated by curve *a*.

Easy Lessons in Engineering

The A-B-C of Chemistry—II

The preceding article showed how to balance an ordinary chemical equation and figure the relative weights where all the materials entering into the reaction and all the products were known. It did not show how to predict what the result would be when two or more substances are brought together. No rule was given by which we could tell whether they would react at all or, assuming they would react, what the products would be. All we know is that the reaction can produce no change in the total weight or in the number of atoms of each element. In general, to predict how substances will react requires a far more extensive knowledge of chemistry than it is possible to give in the limited space here available.

Chemists have an elaborate system of naming substances from their chemical formulas. Some of the more important rules of this system may be discovered by observing the formulas and corresponding names as we go along.

To the power-plant engineer the most important class of chemical reactions is oxidation or the combination of elements (or compounds) with oxygen. When oxidation is very rapid and large quantities of heat are evolved, we have combustion. Take the case of the incomplete combustion of carbon to CO, called carbon *mon*oxide ("mon" standing for "one"). The chemical equation is

$$2\,C + O_2 \rightarrow 2\,CO$$

Parts by weight $24 + 32 \rightarrow 56$

The carbon monoxide produced can be further burned or oxidized to CO_2, the equation for this being

$$2\,CO + O_2 \rightarrow 2\,CO_2$$

Parts by weight $56 + 32 \rightarrow 88$

The CO_2 is called carbon *di*oxide because there are *two* atoms of oxygen in the molecule. In the same way SO_2 is called sulphur *di*oxide and SO_3 sulphur *tri*oxide.

When carbon burns completely to CO_2, it probably burns first to CO, which in turn burns to CO_2. For many practical purposes, however, the complete combustion may be looked upon as a single chemical reaction according to the following equation:

$$C + O_2 \rightarrow CO_2$$

Parts by weight $12 + 32 \rightarrow 44$

An oxide is called "metallic" or "non-metallic" according as the element with which the oxygen is combined is a metal or a "non-metal" (see table in preceding article). If a non-metallic oxide reacts with water, the result is an *acid*.[1] For example, sulphur trioxide (SO_3) reacts with water (H_2O) to produce sulphuric acid (H_2SO_4), the equation being

$$SO_3 + H_2O \rightarrow H_2SO_4$$

[1]This is only one of the many ways in which acids may be formed.

This is one of the reactions that forms corrosive acids in metal smokestacks. In the same way other non-metallic oxides unite with water to form acids as illustrated by the following table:

Non-metallic Oxides		Acid
Sulphur dioxide (SO_2)	forms	Sulphurous acid (H_2SO_3)
Carbon dioxide (CO_2)		Carbonic acid (H_2CO_3)

Acids are distinguished by a sour taste and the fact that they turn blue litmus paper red, as well as by their reactions with metals and bases, as will be explained later.

The metallic oxides react with water to form a class of corrosive compounds called *bases* or *alkalies*. These are very different from acids. For example, they turn red litmus paper blue. A few typical examples of metallic oxides and the bases they produce are given below.

Metallic Oxides		Bases
Potassium oxide (K_2O)	forms	Potassium hydroxide (KOH) (Caustic Potash)
Sodium oxide (Na_2O)		Sodium hydroxide (NaOH) (Caustic Soda)
Calcium oxide (CaO) (Burnt lime)		Calcium hydroxide ($Ca(OH)_2$)

The outstanding characteristic of bases is the readiness with which they react with (or "neutralize") acids, thereby producing a third class of compounds, called *salts*. A common example is the reaction of sodium hydroxide (NaOH) with hydrochloric acid (HCl) to form sodium chloride (NaCl), which is ordinary table salt. The equation is

$$NaOH + HCl \rightarrow H_2O + NaCl$$

The "salt" resulting from the reaction of an acid and a base is always the combination of the metal of the base with the *acid radical* of the acid, the acid radical being all the acid except the hydrogen. In fact, an acid may be defined as a compound containing hydrogen that can be replaced by a metal. The metal may come from a base as just illustrated, or the salt may be, in certain cases, produced directly by the action of the acid on the metal.

The following table shows some of the salts produced from common acids by substituting a metal for the hydrogen:

Acids	Salts
Sulphuric acid (H_2SO_4)	Sodium sulphate (Na_2SO_4)
	Calcium sulphate ($CaSO_4$)
	Copper sulphate ($CuSO_4$)
Nitric acid (HNO_3)	Sodium nitrate ($NaNO_3$)
Carbonic acid (H_2CO_3)	Sodium carbonate (Na_2CO_3)
	Calcium carbonate ($CaCO_3$)
Hydrochloric acid (HCl)	Sodium chloride (NaCl)
	Calcium chloride ($CaCl_2$)
	Zinc chloride ($ZnCl_2$)

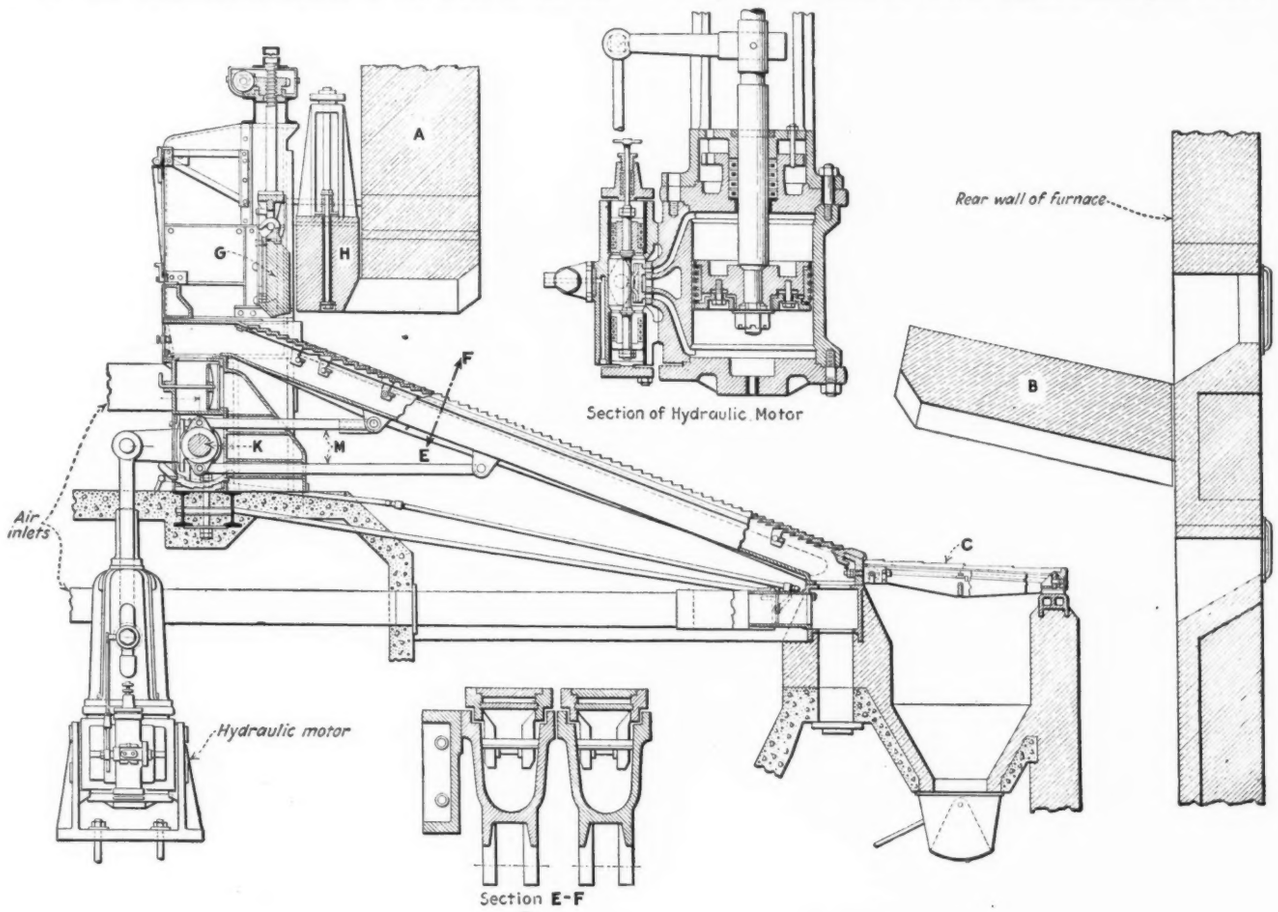
It would be impossible in two such short articles as these to do more than touch some of the high spots of this difficult but important subject. It has even been necessary to omit all mention of two fundamental branches—*valance* and *ionization*. These, however, are not absolutely essential in working ordinary combustion problems, but they should be studied by all who desire a good understanding of such chemical subjects as feed-water treatment.

The Pluto Mechanical Stoker

A recent issue of *Engineering* describes the Pluto Stoker developed by the N. V. Maatschappij Pluto, of Nijmegen, Holland.

The general arrangement of the stoker and setting are shown in the illustration. The grate is in two sections, the front part being inclined downward from the hopper and the back part horizontal. Both sections of the grate are formed of long narrow bars having a horizontal reciprocating motion. The object of the horizontal section of the grate is to reduce the speed of travel of the fuel as it burns, so that the ash and clinker accumulate at the back of the furnace and have ample time for their combustible contents to be well burned out before falling over the end of the grate.

The setting comprises a short front arch *A* and a larger rear arch *B* which reaches almost to the front of the ash



DETAILS OF STOKER AND ARRANGEMENT OF FURNACE ARCHES

bars *C*. This rear arch tends to insure more complete combustion of the fuel. Hoppers are provided below the inclined portion of the grate and also below the ash bars to catch the fine ash and coal that sifts through the grate.

The stoker is operated with forced draft. The air supply is divided, part passing down through the inclined grate bars and discharging through the fuel bed. The remainder is led under the stoker and passes up through the ash bars. The air supply is regulated by means of adjustable dampers.

The grate bars slide on three cast-iron transverse air boxes. The inclined bars consist of hollow troughs machined on both sides and on their sliding faces. On the upper sides of the bars are fitted renewable fire bars, the construction of which will be readily understood by reference to the section *E-F* shown at *D*.

The firedoor *G* consists of a number of brick-lined castings hanging from a horizontal rail, the whole being raised and lowered to provide for different thicknesses of fire by means of the worm and screw gear shown. Directly behind the firedoor is a firebrick sluice *H* also arranged to be raised and lowered. This is fitted only in installations where there is sometimes occasion to burn a very low grade of fuel. In such cases the sluice is opened and a thick fire obtained.

The reciprocation of the fire bars both inclined and horizontal is affected by a rocking shaft *K* running across the front of the grate. Short levers on this shaft are connected to the lugs beneath the grate bars by means of the links *M*.

The hydraulic motor with which the stoker is operated is an interesting feature. It can be worked by water either from the boiler-feed pumps or from other pumps specially provided for the purpose. The stoker can be fitted to any type of water-tube boiler, and with a special setting it can be adapted to cylindrical boilers.

The grates are made in various widths and lengths to suit the different requirements and have a rate of combustion with normal bituminous coal of about 30 lb. per sq.ft. of inclined grate surface, but this can be more than doubled with lignite as fuel. The grates will burn coke mixed with about 10 per cent bituminous coal, and coke breeze is burned alone in some cases.

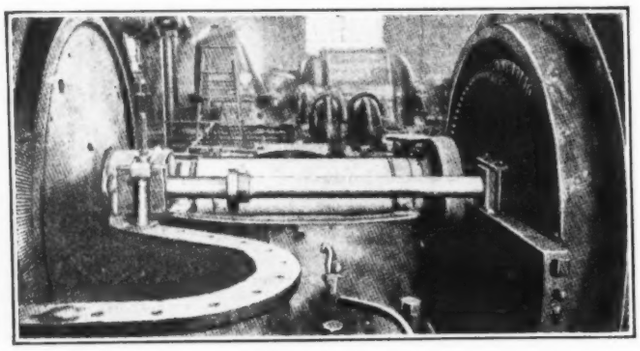
Boiler Code Corrections

Attention is called to several typographical errors in the "A.S.M.E. Boiler Code Interpretations," on page 998 of the June 19 issue. All are found in the reply and discussion on Case 411. The first formula given should read: $P = \frac{CI^2}{p^2} + 250\,\frac{I}{R}$, while the expression in parenthesis at the end of the reply should be $\left(P - 250\,\frac{I}{R}\right)$. In the comments explaining the meaning of the letters, the maximum allowable working pressure, pounds per square inch, should be represented by P rather than by p.

Turning the Main Journal of a Turbine with One Bearing Liner Removed

After many years of operation a 6,000-kw. turbine required the bearings to be rebabbitted and the journal next to the coupling at the generator end smoothed down. As there was no lathe in that section of the country large enough to swing the rotating element, it was decided to turn the journal in place in the wheel casing. The method adopted is well described in an article by N. G. Hardy, chief engineer of the Waco Generating Station, which appeared in the *Texas Utility News of* February.

The journal was 15 in. in diameter by 37½ in. long. The rotating element contained seven turbine wheels of approximately 7½ ft. diameter. The bearing at the governor end



BORING BAR MOUNTED ON GENERATOR AND WHEEL CASING

was retained in place, together with the thrust bearing. The bearing liner at the coupling end was removed, and the shaft was supported by two half-rings, 2¾ in. wide, placed in the bearing housing.

In order to turn the rotating element, the reduction gear from an Underwood boring bar was attached directly on the governor end of the main shaft. A pulley on this reduction gear in turn was bolted to an induction motor. This made it possible to drive the turbine shaft at a speed of 14 to 21 r.p.m.

In order to mount the turning tool, an Underwood boring bar was lined up parallel to the journal and held in two cast-iron blocks, as shown in the figure. One of these blocks was mounted on the turbine casing and the other bolted to the generator frame. The tool was fed by a rope drive.

The journal was polished with No. 2 and then No. 0 emery cloth fastened to a wooden block that fitted the shaft. The finished journal showed a maximum variation, from end to end, of only 0.001 in. of diameter. The final diameter was 14.98 in., which represented 0.017 in. less than the original.

Effect of Ice on Flow of Mississippi River at Keokuk, Iowa*

An interesting effect of ice on stream flow is that which occurs annually on the Mississippi when that stream is changing from open-water to under a solid ice cover. The experience at Keokuk is consistent from year to year because the natural flow of the river is not affected to any great extent by the operation of power plants above. Besides this there is an opportunity to measure accurately through the wheels the flow from day to day.

Another thing which makes the situation at Keokuk unique is the size of the stream, its low velocity, the absence of riffles or controls in the channel and the long distance from Keokuk to the main sources of sustained flow, which come mainly from the Wisconsin and Minnesota lakes. Since the main source of supply is so far from Keokuk, it takes a rather long time, a matter of three weeks, for the complete change from open water to closed channel flow to take place.

The first running ice appears in the river at the head of the lake about Dec. 8 in the average winter, and a solid ice cover on the river north of Keokuk completely forms in about six days. The river north of Keokuk then remains completely closed until about March 1, when the beginning of the final break-up sets in. Altogether, the period of ice effect persists for about 82 days. Out of this the first 20 days represent what is termed at Keokuk the "initial freeze" period.

The operating experience of the last ten years has yielded excellent records of flow and has given ample proof of the following conclusions relating to the Mississippi.

1. That the flow during any winter period will depend mainly on the flow at the time of the first freeze-up.

2. That the initial freeze-up will cut the flow down to 40 per cent of the original flow in six days; it will keep it down close to that figure for five days and then allow it to recover gradually in nine days to a flow between 75 and 80 per cent of the original flow, the average period from freeze-up to full recovery being about twenty days.

The reason for the sudden drop-off in flow is that the blanket of ice holds in check the velocity of the water throughout the drainage. The wetted cross-section later increases to compensate for the reduced velocity. This results in a considerable amount of storage in the form of water, entirely aside from the ice storage, which water is released in a few days when the ice blanket is lifted off the streams in the spring. This is the underlying cause of the floods which invariably accompany the break-up.

The Keokuk Theory

The theory developed at Keokuk is that under a solid ice cover in a stream without a well-defined control the flow will be only about one-half the open-water flow for the same water-surface gage height. The flow in an open river begins to decrease as soon as light running ice appears and continues to decrease until a solid ice cover has formed. Immediately after the solid ice cover has formed, the flow remains constant at somewhat less than one-half the open-water flow until the source supplying the stream has had time to fill up the additional storage area required under the ice cover to accommodate the normal winter flow at the decreased velocity. The volume of water held back over the "initial freeze" goes to increase the cross-sectional area of the stream throughout its length. It is this same volume of water that is released suddenly when the ice breaks up.

The underlying cause of all this is, of course, the fact that an ice cover practically doubles the "wetted perimeter" of a given cross-section and doubles the area of the surfaces producing friction. A general consideration would lead one to expect the velocity of the stream to be halved. While a theoretical consideration of the Chezy and Kutter formula does not show that the velocity is halved by doubling the wetted perimeter, actual experience shows that this occurs. The conditions of flow under an ice cover are so different from open channel flow that it would hardly be expected that constants of one would apply to the other. Flow under an ice cover is more comparable with flow in pipes or closed conduits running full.

In the United States Geological Survey stream-gaging work in southeastern Iowa, it has been found that the flow under an ice cover in a stream without well-defined controls averages very close to one-half the open-water flow for the same gage height. It is true that in many streams the presence of open riffles, power dams, non-uniformity of ice cover, ice jams, etc., may entirely obscure the normal effect previously mentioned. In the streams of the Middle West, however, and especially the Mississippi, the effect is very regular.

As proof of this it might be said that during last winter the flow at Keokuk was predicted for seven weeks in advance with an accuracy of 1 per cent for the total flow in the period. The maximum error on any one day was less than 10 per cent, this error being 2,300 sec.-ft. on Jan. 9 when the flow was 24,300 sec.-ft. The prediction was borne out from day to day in spite of big variations in mean temperature. The prediction was made on Dec. 8 for the period up to Jan. 25. In this period the maximum temperature varied from 16 to 63 deg. and the minimum temperature from 2 to 40 deg. At no time, however, did the ice covers on the streams threaten to move out.

*Abstract from the N.E.L.A., 1923, Hydraulic-Power Committee's Report.

This experience is cited to show that flow over the "initial-freeze" period obeys laws as definite as those governing open-channel flow. It is certain that there is no time in the whole year when the flow at Keokuk may be predicted far in advance with more accuracy than during the winter period.

The idea of water being held back by a series of ice jams at the beginning of the freeze-up is a common and convenient one, but it is not the main cause.

In further confirmation of the effect of a solid ice cover on velocity, it has been observed repeatedly in the 40-mile lake above the dam that back water slopes under a reasonably smooth ice cover are practically twice the slope under open water conditions where the flow is the same. Since there is no appreciable change of cross-section in the lake, it is apparently necessary to have twice the slope to produce the same velocity. This is the converse of the previous statement that in a normal stream where the slope cannot change, the velocity is halved by presence of an ice cover.

A matter of interest in connection with the prediction of winter flow at Keokuk is the way in which the water temperature and up-river stations are watched to anticipate the formation of ice and the consequent drop in flow.

It has been found that the flow begins its drop on the day following the appearance of floating ice in the main river at a station about 170 miles above Keokuk; that the drop begins to be pronounced when floating ice is reported from Keithsburg, 65 miles above the dam; that floating ice appears in the Iowa streams on the day preceding the appearance of floating ice in the main river at Keithsburg.

From a study of water temperatures it has been observed that as soon as the river-water temperature has fallen to 35.0 deg. F. with temperatures well below freezing, floating ice will appear. By watching water temperatures it is possible to know when either surface or frazil ice cannot form and when conditions are favorable for their formation.

The water thermometer used is of the direct-reading mercury type, but graduated to tenths of degrees Fahrenheit and capable of being read to hundredths of degrees by estimation. It is inclosed in a water thermometer case of the standard Weather Bureau type. Regular readings are taken every three hours and special readings every half hour as necessary.

Several operating companies have in connection with this article recorded their experiences, and these coincide with conditions at Keokuk in a general way.

Canadian Association of Stationary Engineers Meet in Toronto

The thirty-fourth annual convention of the Canadian Association of Stationary Engineers was held at Toronto, June 25-28.

There were upward of forty delegates in attendance, made up largely by the members of the local association. The engineers held morning and afternoon sessions during the four days. Several important measures were brought before the delegates for deliberation, the most important of which was a resolution for a new membership drive and the awakening of interest in the various local bodies. Although the attendance of delegates was unusually light this year, as many could not be spared from the plants, the educational work was fully up to the standard and some carefully prepared and instructive papers were read and discussed.

The meetings of the delegates were held in the lecture room of the Central Technical school building, and the three large assembly rooms adjoining were arranged for the use of the Canadian Exhibitors' Association in the display of power-house equipment and mechanical devices of various kinds. About forty firms occupied booths.

On Monday evening the convention was called to order by R. McLaren, president of the local association, and an official address of welcome was given by W. S. Kirkland, first assistant principal of the night technical department, after which an inspection of the department was made, conducted by M. B. Watson, director of the engineering branch of the school.

On Tuesday and Wednesday evenings entertainments were held in the auditorium. Organ recitals were given by G. H Graham and Howard Fletcher. Amusing motion pictures were shown, also an instructive engineering film dealing with combustion, which was explained by G. G. Mills. E. F. Hetherington sang solos and Jack Armour, of *Power*, told stories and gave recitations.

The feature of entertainment was the banquet at the Carls-Rite Hotel on Monday evening. Two hundred covers were laid in the main dining hall. After the coffee was served, the toastmaster, M. Thompson, introduced the following speakers, who gave brief addresses on subjects of interest to the diners: R. McLaren, president of the Toronto local association; M. B. Watson, director of engineering of the technical school; J. H. Ballantyne, Deputy Minister of Labor; Alderman W. H. Shaw; J. H. Brown, chairman Board of Engineers; J. L. Burke, chief factory inspector.

On Wednesday morning Mayor Alfred C. Maguire addressed the convention in the auditorium. He spoke of the manufactories and other important industries of the city. He said that Toronto was a home town and that 70 per cent of the residents owned their homes; this was because of the high rate of wages paid to the skilled mechanic and to the workman.

The following grand officers were elected by the engineers: J. J. Sullivan, president, Ottawa; Robert McLaren, vice-president, Toronto; H. E. Groom, treasurer, Kensington; George J. Soucey, secretary, Toronto; John McAuley, conductor, Woodstock; Joseph Ward, doorkeeper, London.

The Canadian Exhibitors' Association elected officers as follows: Howard Fletcher, Garlock Packing Co., president; Earl Gordon, Thompson-Gordon Co., First vice-president; H. Hattfield, Babcock Wilcox Co., second vice-president; Lloyd M. Archibald, Dart Union Co., treasurer; Gordon C. Keith, *Canadian Manufacturer*, secretary; George M. Wilkinson, Quaker City Rubber Co., assistant secretary. Montreal was voted as the next convention city, the meeting to be held in June, 1924.

Connecticut State Association of Stationary Engineers Hold Annual Meeting

The twenty-eighth annual convention of the Connecticut State Association of the National Association of Stationary Engineers was held at Waterbury, June 29-30, with headquarters at the Hotel Elton.

There were fifty delegates present, and the business meetings were conducted with harmony and dispatch. The reading of reports showed a net increase of 37 members throughout the state. Energetic committees were appointed covering all the cities of Connecticut, and an earnest and united endeavor will be made this winter to put through a state license law. There was much rejoicing among the delegates when the Bridgeport Association re-joined the state association.

The opening ceremonies were held in the Knights of Pythias Hall on Friday evening, with National Conductor B. M. Doyle presiding. Mr. Doyle spoke briefly in expressing his appreciation of the big attendance. Charles Harder, secretary to the Mayor, and Alvin Gillett, of the Chamber of Commerce, made addresses of welcome. Brief remarks were also made by William Burnham, Thomas H. Platt, A. J. German and P. J. Grace. The gavel was then handed to Charles F. Ceilley, of the *National Engineer*, who acted as master of ceremonies, and introduced the following entertainers: Mr. Serre and Joe McKenna; Judins Bros.; Bill Jones of Tide Water Oil Sales Co.; and Jack Armour, *Power*.

The Connecticut Supplymens' Association was formed on Saturday morning. The officers elected included Frank A. Bulkley, Anchor Packing Co., president; Thomas H. Platt, Dearborn Chemical Co., vice-president; Harry Glyune, C. S. Mersich Co., secretary-treasurer.

The following officers were elected: F. C. Sutorius, New Haven, president; Mr. Holland, Norwich, vice-president; G. F. Klopfer, New Haven, secretary-treasurer; Mr. Blake, Hartford, assistant secretary; Mr. Bressingham, Waterbury, conductor; Mr. Hughes, Bristol, doorkeeper.

The Engineer's Incomplete Mastery of Power*

By Thomas T. Read†

The mastery that the engineer has attained over mechanical power is really quite remarkable and not only reflects great credit upon himself, but has profoundly affected the whole of society. Too much emphasis cannot be laid upon the fact that through the skill of the engineer the average man has been lifted from a position in which he had to perform hard and monotonous work to a position in which he is really an executive. In this country, where the output of every worker is supplemented by that of 33 invisible slaves of power, the combined output is large enough to provide everybody, on the average, with a large measure of comfort and convenience. The most notable contribution that the engineer has made to society is that he has set free most men from the necessity of doing hard physical work and has given them the opportunity to use their brains in the direction of mechanical forces.

The engineer may be defined as one able to apply power in the most efficient way, to the performance of whatever needs to be done. As far as mechanical power is concerned, the engineer has been highly successful.

There are, however, other definitions of power. For example, the dictionary defines power as the "right, ability or capacity to exercise authority." The engineer has, as yet, attained a very incomplete mastery of this kind of power. That is, the engineer has only to a very limited extent demonstrated his capacity to exercise authority in political and similar matters. The proper way in which to exercise authority is to inform and convince people of what ought to be done, because if they are informed and convinced, they will do it without any compulsion. Now, informing and convincing people is an art in itself and one in which the engineer, on the average, exhibits little skill. The engineer seems to feel that the facts in any case ought to be sufficient. All he has to do is to tell people to come and get them. Unfortunately, they will not do it. If the engineer entertains the idea that he can secure the attention of the world and inform and convince people without making a careful and well-directed effort to do so, he is greatly mistaken. Unless the engineer learns both to talk and to write so that what he has to say is not only easy to understand, but also sufficiently interesting to capture the attention of those to whom it is addressed, he will never be in a position to exercise the authority that his ability and importance entitle him to.

It has often been pointed out that among those who exert political power there is a large proportion of lawyers, as compared with the proportion which lawyers form in the average of population. The reason for this is quite obvious—it is a lawyer's business to inform and convince juries in order to win his cases, and he studies and practices the art with the same care as a musician studies and practices his art. Frank Gilbreth is fond of saying that "rhetoric is superior to logic," by which I suppose he means that rhetoric unaided by logic will "get across," while logic unaided by rhetoric will not, which is certainly true. Until the engineer adds rhetoric to his logic, he cannot expect to put his ideas across in public life.

My plea is, therefore, that the engineer's mastery of physical power is not sufficient and that he must seek to acquire mastery over those forms of power that cannot be measured in kilowatts or horsepower; because such forces cannot be measured, the engineer has perhaps thought them unworthy of his attention, and yet they affect our lives more profoundly than mechanical forces do and, like mechanical forces, they can be directed and controlled. Two of the most important of these less-tangible forms of power are power of will and power of imagination. The importance of the former is well understood. The power of imagination is the wonderful force that is the basis of all literature and art, and it is also back of great projects, such as the building of railroads, bridges, new inventions, etc.

Perhaps the most serious lack of imagination of the engineer is his general inability to imagine how other people can think and feel differently from himself about the things of importance. Some years ago a group of well-known engineers, having decided that the laws on a certain subject needed to be revised, sent a delegation to Washington to have it done. They hired a large auditorium and sent invitations to all members of Congress to come hear them explain what needed to be done. Unfortunately, none of the Congressmen came except those who were on the program to speak. They arrived just before they were scheduled to speak and left immediately afterward. The course followed by the engineers to obtain the desired reform had all the pathos of the famous Children's Crusade of the Thirteenth Century, because imagination should have informed them that the means taken would not produce the results desired. Many other examples might be cited, but this one will suffice to illustrate my point that the engineer is woefully devoid of imagination concerning those things that are outside of his immediate field of work.

Other forms of power which must be considered are power of instinct and power of emotion. The practical importance of emotion, in its many manifestations, such as fear, hatred and humor, can hardly be overestimated. If there were time, I would like to argue to you that fear handicaps many an engineer, for the fear to venture "hamstrings" achievement.

As to humor, a wise friend, manager of a plant, tells me that whenever relations between him and his employees become strained, he always tries to make them laugh, because when humor is injected into the situation, a sane discussion becomes possible. Humor is the lubricating oil of the mental machinery of the world, and the engineer who can laugh and make others laugh has a mastery of that kind of power which can do most to produce the happiness which is generally agreed to be the fundamental aim of life.

*Abstract of address delivered at the ninth annual convention of the American Association of Engineers, held in Norfolk the first week in May.

†Supervising Mining Engineer, United States Bureau of Mines.

Loss of Head

Tests were recently made at the University of Wisconsin to determine the loss of head in valves and pipes of ½ to 12 in. diameter. The results obtained were later described in Engineering Bulletin No. 1, Vol. 9, wherein the conclusions were summarized as follows:

The loss of head due to valves and other fittings occurs in part within the valve or fitting and in part as an added loss in the pipe line downstream where normal flow has been disturbed.

Measurement of the loss of head where the downstream piezometer is attached too near the valve will give a loss in excess of that actually produced. From 20 to 25 pipe diameters beyond the valve will probably give the best position for the downstream piezometer opening. It is undesirable to have a greater length of pipe in the gage length than is actually needed to include all valve loss.

The loss of head in new clean wrought-iron pipe from ½ to 12 in. in diameter is given approximately by the formula $H = \frac{0.0319}{d^{1.16}} v^{1.9}$, in which H equals loss of head in feet per 100 ft. of pipe, v is the velocity of flow in the pipe in feet per second, and d is the pipe diameter in feet.

Globe valves offer from 15 to 40 times the resistance of gate valves for the same size. This ratio increases with the increase in the size of valves.

The length of straight pipe of the valve size which will produce the same loss of head varies from ¾ to 4 ft. for fully open gate valves and from 20 to 35 ft. for fully open globe valves. In the case of globe valves the smaller valves are equivalent to the greater length of pipe measured in pipe diameters.

In olden times the saying "Like carrying coals to Newcastle," was supposed to express the height of stupidity but that is what the coal carrying industry has been engaged in at various times during the last three years. The United States is sending coal literally to Newcastle and Newcastle not to be outdone is sending her coal to the United States. Another sign that we have not mastered even the rudiments of economic distribution.

News in the Field of Power

Hudson River Regulating Commission Plans 15 Storage Reservoirs

Plans for $15,000,000 Project to Regulate the Hudson River Watershed Filed in Twelve Counties

PLANS for an engineering proposition involving the ultimate expenditure of $50,000,000 in the construction of fifteen storage reservoirs for regulation of the flow of the Hudson River watershed were filed June 28 in twelve counties in which the reservoirs will be constructed by the Hudson River Regulating Commission.

The creation of river regulating districts was authorized by Article 7-a of the New York State Conservation law as added by Chapter 662 of the Laws of 1915. The Hudson River Regulating Commission was appointed by Governor Miller in 1922.

Under the provisions of the law a river regulating commission prepares plans for the construction of reservoirs and the general regulation of the flow of streams. The financing of the project is to be accomplished by the issue and sale of bonds which will ultimately be paid for by the assessment and collection of taxes from the territory benefited.

The largest of the fifteen authorized reservoirs will be the Sacandaga, which will be created on the site of an old lake bottom which probably dates back to the stone age. In its creation four villages will be submerged, as well as parts of two others. The proposed Sacandaga reservoir will in reality be a new lake, about thirty-five miles long, which, the commission announced, will probably match Lake George, not only in size but also in beauty.

A dam for the creation of the reservoir will be built in the village of Conklingville, Saratoga County, part of which will be submerged. The reservoir will be triangular in shape with the southern point at Conklingville and the two northern points at Northville and North Hampton. Part of Sacandaga Park, long famous as a summer resort, will be submerged, while the rest of it will lie on the bank of the new lake.

Other reservoirs will be constructed at Boreas Ponds, Cedar River flow, Chain Lakes, Cheney Ponds, Goodenow, Indian Lake, Lake Pleasant, Ord's Falls, Piseco Lake, Schroon Falls, Shushan, Thirteenth Lake, Trout Brook and Warrensburg.

In the Hudson River regulating district are located the counties of Albany, Columbia, Essex, Greene, Fulton, Hamilton, Rensselaer, Saratoga, Schenectady, Schoharie, Warren and Washington, and it is upon the cities, towns and villages in these counties that the cost of construction will fall.

The filing of the approved development plans for the construction of the reservoirs is the final step to be taken before construction begins. The plans for actual construction work are now being prepared.

The Hudson River Regulating Commission consists of former Senator Henry Sage, of Albany, Erskine C. Rogers, of Hudson Falls, and Edgar H. Betts, of Troy. The commissioners receive $10 a day while actually engaged in the work of the commission.

"The importance of this comprehensive plan to scores of industrial plants owning and using water power on the Hudson and to the several cities and villages along the river, which will be benefited by a constant stream flow and the control of flood waters, can hardly be overestimated," said a statement from the commission.

Aside from the promised guaranty of power and the prevention of floods, advantages claimed include an annual saving in coal of approximately 2,000,000 tons and an increase of the minimum flow at Albany from approximately 1,000 sec.-ft. to more than 5,000 sec.-ft., increasing the depth of water in the channel by about eighteen inches, thus aiding navigation and improving sanitary conditions. It is also estimated that the project, when completed, will make possible the harnessing of 200,000 additional horsepower in the capital district, the dams required for the reservoirs being utilized as a part of a hydroelectric development system.

Thus the river regulating plan performs two functions—the regulation of the flow of streams and the development of latent power. It is, briefly, a system under which the state lends its authority to the private development of water power under conditions meant to protect the state's interests completely. For instance, while the owners of water powers in the Hudson watershed assume the full burden of cost of power development, all the land and works constituting a regulating reservoir become the property of the state without expense to the state. The power interests obtain only a fifty-year lease on the property, which must be conducted as to finances, operation and rates in all respects as the state decrees. While the state will collect through its tax department the assessments levied upon property benefited by the improvement, this money being applied to interest on bonds, a sinking fund and reimbursement to the state for its expense, the state is not liable for either principal or interest on the bonds, which bonds are issued by the regulatory district commission, which for such purpose is a body corporate.

It is estimated that the storage project will be completed within about five years.

Board of Boiler Inspectors Stamps Acceptable

The National Board of Boiler and Pressure Vessel Inspectors have notified the members of the American Boiler Manufacturers Association that, as of June 23, the following states and cities will accept National Board stamping and numbering in lieu of state standard stamps: States—Arkansas, California, Indiana, Maryland, Minnesota, New Jersey, New York, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, Utah, Wisconsin; cities—Chicago, Ill.; Kansas City, Mo.; Nashville, Tenn.; Parkersburg, W. Va.; St. Louis. Mo.; Seattle, Wash.

Diesel Engines To Supply Power To Transmission Lines

The Central Power and Light Co., St. Louis, Mo., has acquired a number of utilities, including ice, light and street-railway plants in Texas. In the list are a number of towns in the lower Rio Grand Valley, including Laredo, Del Reo, Alice, Corpus Christie, Beeville, Victoria, Cuero and Kingsville.

Recently, the plants at Mission, Mercedes, Phara and Donna San Benito have been purchased and the management has decided to build a central plant and connect these several towns by a 66,000-volt transmission line. The initial installation will consist of two 1,150-hp. Busel Sulzer Diesels direct-connected to 750 kw. alternators. The diversity of load will result in a comparatively high load factor, and the Diesels are expected to deliver 11 kw.-hr. per gal. of fuel oil. The holding company operates 12 other Diesels, totalling 5,295 hp.

Southern Trade Congress To Be Held in New York City

The Southern Trade Congress will be held at the Majestic Hotel, Seventy-second Street and Central Park West, New York City, July 9-11. The object of the convention is to increase the trade of New York City with the Southern and Southwestern States and with Pan-America.

American Marine Congress to be Held in N. Y. City, Nov. 5-10

The American Marine Congress has been called, by the American Marine Association in collaboration with the U. S. Department of Commerce, other government departments and a great number of allied organizations including manufacturers, commercial, export, trade, transportation, farm and labor groups, for the week of Nov. 5-10, which is to be called Marine Week.

Throughout all industry, where ships are concerned, there is a great need for unity of purpose, to the end that a definite and satisfactory shipping program may be produced. The policy of this Congress will be one of self defense for American shipping and will function along the following lines:

To urge the modification of statutory restrictions or laws which tend to burden the world-wide competing capacity of American ships, but at the same time to maintain or establish all necessary restrictions pertaining to the safety of passengers and crews, protection of goods and protection of rights, quarters and living standards of American crews; to urge adoption of new legislation to increase world-wide competitive capacity of American ships; modification and changes in the steamship code; to aid in favor of building and repairing in American shipyards, with American labor and materials; standardization of construction and operation to decrease costs; to urge the repeal of legislation which favors government agencies competing with private ship yards; to consider and make recommendations concerning government-owned ships competing with privately owned ships; to consider advantage of reciprocal agreements with foreign lines.

Mr. Hoover expressed the belief that this was the best effort he had yet heard of and further stated that the shipping problem was one of the great national questions and that no satisfactory progress could ever be made unless all groups of the nation's representative industries were included.

Engineers Report Adversely on Oil For Federal Heating Plant

Change from a coal-consuming to an oil-burning basis in the heating plant of a federal government institution in the District of Columbia is opposed in a report by the Mechanical Engineering Division of the United States Bureau of Mines, which recently conducted efficiency tests at the plant, on the ground that consideration of conservation of national resources leads to the conclusion that oil should not be used in stationary plants which show such small computed savings over using coal.

By a slight change in the furnace the Bureau of Mines engineers pointed the way to fuel economies at this plant. The tests showed variations in efficiency among the three shifts in the fireroom.

The report states that the plant could be changed to an oil burner at a cost of $33,500, to be amortized in five years. Assuming that oil could be contracted for at 3.5c per gal. as contrasted with New River coal at $8.18 per ton, it is estimated the plant could save only $2,400 a year by changing to oil.

Oil is one of our national resources which is limited in extent and must be conserved for military, naval, merchant marine and lubricating needs. To use it extensively in stationary plants brings nearer the time when the supply will be exhausted and the above needs for its best use will have to seek supplies in some other form.

At present oil prices are low and therefore favorable to plants desiring to change from solid to liquid fuels, but no one can predict how long such conditions will exist. It is certainly true that a plant changing from coal to oil now will have to revert to coal again in the not too distant future. It seems advisable from a national resources standpoint that this plant continue on a coal-burning basis and bend their energies toward improvement in coal efficiency rather than seek a change to fuel oil now and later on change back.

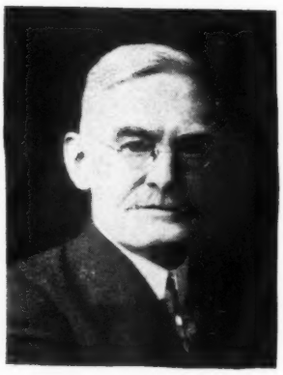
The tests disclosed conditions which resulted in shortening the ignition arches 18 in. in consequence of which the over-all efficiency was increased 2 per cent; the thermal efficiency of the boiler alone increased 4 per cent, while the heat absorbed by the superheater and by the economizer decreased 1 per cent each; and the temperature of the gases leaving the boiler decreased 108 deg. while the rate of working the boilers decreased 20 per cent. Previously, the steam pressure tended to fall continuously and to maintain it at the proper point the fuel bed had to be poked frequently. The poking of the fires broke up the caked fuel, which was then carried onward by the stoker. After the ignition arch was shortened, poking was resorted to only one-fourth as frequently, while the steam pressure was held five pounds higher with a maximum fluctuation of five pounds compared with a previous fluctuation of fifteen pounds. Also, it was not necessary after the change to blow the ash from the tubes, which had been done frequently previously in order to avoid complete obstruction, as the accumulation was negligible.

It was shown that the day shift carried the heaviest load with the least losses, the afternoon shift was second and the night shift third. The difference among the shifts in part was described to changes in the load, but greater losses in dry gases by the afternoon and night shifts than the day shift were attributed to the fact that these shifts were not so attentive to their fires as was the day shift.

The tests indicated that if the plant is operated as well for the whole year as it was during the tests, there will be an annual saving of approximately $10,000 in fuel cost.

Obituary

John Alexander Britton, vice-president and general manager of the Pacific Gas and Electric Co., and one of the well-known men connected with the gas and electric field died suddenly on June 29. Born in 1855 in Boston, he studied in the public schools of that city until he was thirteen years of age, when he moved to California and entered the law office of Charles A. Lowe, of San Francisco, as a clerk. He continued his law studies until 1874, then entered the employ of the Oakland Gas Co. as a clerk and collector, remaining with the company in various capacities until finally he became president in 1901.



JOHN A. BRITTON

He was also vice-president and general manager of the California Gas & Electric Corp. from 1903 and has been vice-president of the Pacific Gas & Electric Co. since 1905, and chief engineer since 1908. An active and enthusiatic supporter of all electrical activities, Mr. Britton, besides directing one of the largest generating and transmission systems in the world, took an active part in the affairs of electrical and other societies, being past president of the Pacific Gas Association and a vice-president-elect of the N.E.L.A. He was also a member of the A.S.M.E. and the A.I.E.E. and a contributor to technical journals on the subjects of gas and electricity.

James P. Marsh, until three years ago president of James P. Marsh & Co., steam specialty manufacturers at 118 South Clinton St., Chicago, died at his home, 3222 South Michigan Ave., on June 27 at the age of eighty-two. Lockport, N. Y., was the birthplace of Mr. Marsh, who came to Chicago in 1860 and five years later founded the business that bears his name, remaining in active control until three years ago. During this long period he has been prominent in the heating business. Starting with the manufacture of steam, vacuum, air and pressure gages for all purposes, he later introduced the Marsh "Acme" automatic air valve for radiators, patented the Marsh Paul Auto-

matic air valve with sealed adjustment, added steam and radiator traps to the line and originated the Marsh system of vapor and vacuum heating. Two married daughters survive Mr. Marsh—one the wife of John J. Abbott, vice-president of the Continental & Commercial Bank, and the other the wife of Judge Washburn.

Personal Mention

Frank J. Shipman, of the Texas Co., has been chosen vice-president of the American Marine Association.

J. Barraja-Frauenfelder, formerly with the Lake Torpedo Boat Co., has accepted the position of consulting Diesel engineer with the Sun Shipbuilding Co., Chester, Pa.

Walter M. McFarland, of the Babcock & Wilcox Co., has been elected chairman of the administrative committee of the American Marine Congress.

Edward J. Flynn, well known in N. A. S. E. circles in New York, Connecticut and New Jersey, has accepted an engagement with the Union Steam Pump Sales Co., 30 Church St., New York.

John W. Lane late editor of the *National Engineer*, **John P. O'Connor**, and **Fred W. Raven**, secretary of the National Association of Stationary Engineers, a souvenir postal card advises us, have found friend Mathot at Brussels.

Thomas H. Carey, formerly with the Globe Indemnity Co., has joined the organization of the New York Indemnity Co., 115 Broadway, New York City, to take charge of the underwriting of steam boilers, engine and flywheel business, as well as supervising the inspection and the safety engineering work.

William B. Mayo, chief engineer for Henry Ford who has been a member of the Detroit Municipal Railway Commission for some years has been offered and has accepted the position of general manager of this city-owned trolley system. His connection with the Ford company will not be severed.

Samuel B. Flagg has been made special representative in New York of the Sanford Riley Stoker Co., of Worcester, Mass. Mr. Flagg for several years was engaged in fuel studies for the United States Bureau of Mines, and for the last six years has been a fuel specialist on the staff of the Electric Bond & Share Co. He is chairman of the subcommittee on fuels of the N.E.L.A. and member of the fuels committee of the A.S.M.E. committee on power test codes.

Business Notes

Manning, Maxwell & Moore, Inc., who handle a large line of power-plant specialties, announce a change of address after July 1, to Pershing Square Bldg., 100 East 42nd St., New York City.

The Orton & Steinbrenner Co., 608 South Dearborn St., Chicago, Ill., manufacturer of locomotive cranes, dipper shovels and grab buckets announces a reorganization of the company and the election of the following officers: P. A. Orton, president and general manager; E. B. Ayers, vice-president; Herbert Mertz, secretary and sales manager; Harry Shaffer, treasurer and purchasing agent; G. L. Niederst, chief engineer; Alex Orton, works manager.

Coming Conventions

American Institute of Electrical Engineers, F. L. Hutchinson, 29 West 39th St., New York City. Pacific Coast Convention at Del Monte, Calif., Oct. 2-5.

American Institute of Mining and Metallurgical Engineers; F. F. Sharpless, 29 West 39th St., New York City. Annual meeting at Ontario, Quebec, Canada, Aug. 20-31.

American Society of Mechanical Engineers, Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 3-6.

Association of Iron & Steel Electrical Engineers; J. F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Iron and Steel Exposition at Buffalo, N. Y., Sept. 24-28.

American Society of Refrigerating Engineers, William H. Ross, 35 Warren St., New York City. Nineteenth Annual Convention at New York City, Dec. 3-5.

International Union of Steam and Operating Engineers; Dave Evans, 6334, Yale Ave., Chicago, Ill. Annual convention at Detroit, Sept. 10-15.

National Association of Practical Refrigerating Engineers; Ed. H. Fox, 914-25 East Jackson Blvd., Chicago. Fourteenth Annual Convention at Memphis, Dec. 12-16.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Buffalo, N. Y., Sept. 10-15. Annual conventions and exhibitions of the State Associations scheduled as follows: **Michigan** at Flint, July 18-20. E. C. Smith, 308 Vine St., Kalamazoo, Mich. **New England States Association**, at Manchester, N. H., Manchester Hotel, July 12-14; Freeman L. Tyler, 32 Briggs St., Taunton, Mass. **Pennsylvania**, at Buffalo, Sept. 9-10; J. N. Calvert, Crafton Sta., Pittsburgh, Pa. **New York**, at Buffalo, Sept. 9-10; W. T. Meinzer, Third St., near Warburton, Bayside, L. I., N. Y. **Minnesota**, at Duluth, Aug. 8-10; C. A. Nelson, 800 22d Ave. N. E., Minneapolis.

National Safety Council, W. H. Cameron, 168 North Michigan Ave., Chicago, Ill. Twelfth annual congress at the New Statler Hotel, Buffalo, N. Y., Oct. 1-5.

New England Association of Commercial Engineers; James F. Morgan, 53 Devonshire St., Boston, Mass. Power Show at Mechanics Bldg., Boston, Mass., Oct. 29-Nov. 3.

The New England Water Works Association; Frank J. Gifford, 715 Tremont Temple, Boston, Mass. Annual Convention at Burlington, Vermont, Sept. 18-21.

National Exposition of Power and Mechanical Engineering; Charles F. Roth, Room 1102, Grand Central Palace, New York City. Power Show, Dec. 3-8.

Society of Naval Architects and Marine Engineers, Daniel H. Cox, 29 West 39th St., New York City. Annual meeting at New York City, Nov. 8-9.

Universal Craftsman Council of Engineers; John F. Amos, P. O. Box 299, Rochester, N. Y. Convention at Rochester, N. Y., Aug. 7-11.

The Pelton Water Wheel Co. announces that **E. M. Breed**, who for several years has been assistant manager of sales, has been appointed sales manager, with headquarters in San Francisco.

Trade Catalogs

Electrical Supplies — Westinghouse Electrical & Mfg. Co., East Pittsburgh, Pa., Catalog of Electrical Supplies, 1923-24, contains 1,303 pages, arranged under subject. It is filled with descriptions, illustrations and data on things electrical.

Pipe.—Continental Pipe Manufacturing Co., Seattle, Wash. Catalog No. 18 is a cloth-bound book of 246 pages, giving, besides descriptions and illustrations of wire-wound wood pipe, continuous stave-wood pipe and creo-wood flume, many useful tables such as specific gravities and weights, hydraulic and miscellaneous data, solutions of triangles, laws of falling bodies, capacities of pipe of different diameters, pressures of water, flow of water through wood pipes, etc. Maps and unusual photos of installations enliven this attractive and useful catalog.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	June 25, 1923	July 2, 1923
Pool 1,	New York	$3.50@4.00	$3.50@3.75
Smokeless,	Columbus	3.50@3.75	3.50@3.75
Clearfield,	Boston	2.00@2.75	2.00@2.75
Somerset,	Boston	2.25@3.00	2.25@3.00
Kanawha,	Columbus	1.75@2.00	1.75@2.00
Hocking,	Columbus	1.75@2.00	1.75@2.00
Pittsburgh No. 8	Cleveland	1.85@1.95	1.90@2.00
Franklin, Ill.	Chicago	3.00@3.25	2.75@3.25
Central, Ill.	Chicago	2.00@2.25	2.00@2.25
Ind. 4th Vein,	Chicago	2.50@2.75	2.50@2.75
West Ky.,	Louisville	1.65@1.85	1.65@1.85
S. E. Ky.,	Louisville	2.00@2.25	1.75@2.25
Big Seam,	Birmingham	1.85@2.25	1.85@2.25

FUEL OIL

New York—July 5, Port Arthur light oil, 22@25 deg. Baumé, 5⅜c. per gal.; 30@35 deg. 5¾c. per gal., f.o.b. Bayonne, N. J.

Chicago—June 29, 24@26 deg. Baumé, $1.97 per bbl.; 32@36 deg., $2.27 per bbl., tank cars.

St. Louis—June 26, tank-car lots, f.o.b. St. Louis: 24@26 deg., $1.85 per bbl.; 26@28 deg., $1.95 per bbl.; 28@30 deg., $2 per bbl.; 32@36 deg., gas oil, 4⅜@5c. per gal.; 36@40 deg., distillate, 5½c. per gal.

Pittsburgh—June 28, f.o.b. local refinery, 30@34 deg., fuel oil, 4¾c. per gal.; 36@40 deg., fuel oil, 5¾c. per gal.; 34 deg., neutral, 8½c. per gal.

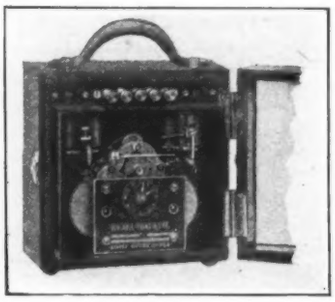
Dallas—June 30, f.o.b. local refinery, 26@30 deg., $1.48 per bbl.

Cincinnati—July 3, tank car lots f.o.b. local refinery, 26@30 deg. Baumé, 4¾c. per gal.; 30@32 deg., 5c. per gal.; 38@42 deg, distillate, 6¼c. per gal

Condensed-Clipping Index of Equipment

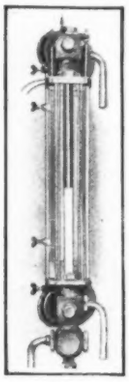
Condensed from previous descriptions in "Power" for convenient filing

Timing Device, Portable "Power," 1923.
General Electric Co., Schenectady, N. Y.



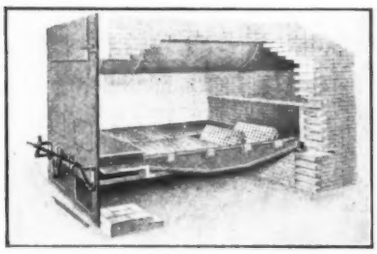
This timing device, which is intended to supplant the stop watch, consists of an incased clock to be used with a standardized clock, relays and a gear train which by adjustments can be set to meet different demands of service. Power is supplied from a local flashlight-type battery. It can be used with graphic instruments; for measurements of angular velocities; for indicating a definite time interval ranging from one second to any whole number of minutes; for checking rotating standards and test meters.

Illuminator, Water Gage "Power," 1923.
National Boiler & General Insurance Co., National Bldg., St. Mary's Parsonage, Manchester, England.



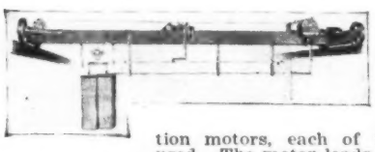
This illuminator is designed to overcome the difficulty of seeing the level of the water in the gage glass, especially where the gage is located at a considerable height above the floor and is not easily read. The fitting is made of sheet brass with cast clamps for attachment to water gage. It is applicable to most types of water gages and can be fitted without tools.

Grate, Rocking Perforated "Power," 1923.
Marion Machine, Foundry & Supply Co., Marion, Ind.



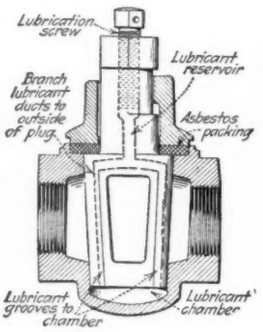
The pin-hole grate ordinarily used for burning fuel too fine to be fired upon ordinary grate bars is now available in the rocking form. The perforations are three-, four- or five-sixteenths of an inch in diameter and spaced $\frac{3}{4}$ in. apart, giving a uniform distribution of air to the fuel bed. The bearings are set loosely in the side frames and held by latch pins, the steel trunnions being cast into the grate. The joints between the segments and those at the side frames and center are beveled. The grates are made one or two sections wide as desired and in long furnaces may be arranged so that the front and back sections may be dumped separately.

Ice Crane, Electric "Power," 1923.
Curtis Pneumatic Machinery Co., St. Louis, Mo.



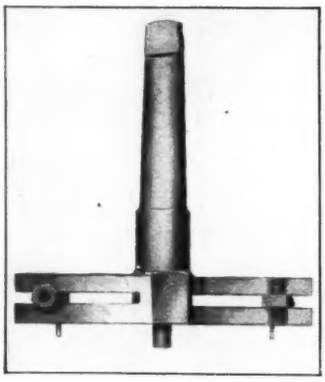
An ice crane has been designed which can be made up as a one-, two- or three-motor crane. It is of light section and occupies little headroom. Standard constant-speed or squirrel-cage induction motors, each of the same hp. rating, are used. The motor leads are placed inside of a conduit, and energy is brought to the motors in a heavy rubber-covered cable on the same trolley wire used to carry the hose for the pneumatic crane. The hoist motor, worm-geared to the hoisting cable drum, is placed on the bridge next to one truck and the trolley motor and gear on the other end. At the center of the bridge is the propelling motor. The pivot suspension of the bridge motor, trolley motor and gears keeps them in alignment with the crane. A disk clutch allows gradual starting and stopping and the use of a worm drive reduces the noise of operation. The motor controls can be operated with one hand. An automatic limit stop device has been inserted on the motor for hoisting and lowering and also on the motor for trolley travel.

Valve, Lubricated Plug "Power," 1923.
The Merrill Co., 90 West St., New York City.



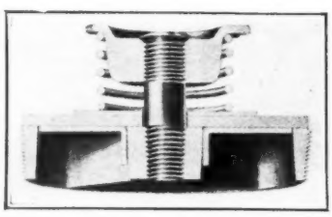
The Merco-Nordstrom plug valve, suitable for boiler blowoff and other purposes, contains a lubricant reservoir in the stem and a chamber in the base, connected by grooves on the surface of the plug, as shown. When the lubrication screw is turned down, lubricant is forced down through the grooves into the chamber below the plug, filling the latter. Pressure sufficient to lift the plug slightly from its seat, no matter how badly frozen, is transmitted, thus permitting easy turning of the valve and lubrication of the seat and plug. Lubricants of all kinds are furnished in convenient cartridge form. The valve is made of cast-iron, semi-steel, brass, bronze, aluminum, "duriron," etc.

Cutter, "Jiffy" Drill Press "Power," 1923.
Paul W. Koch & Co., 19 S. Wells St., Chicago.



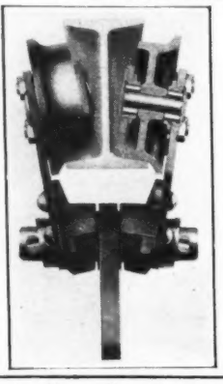
This cutter has been brought out to take the place of the makeshift flycutter used in so many shops. There are two sizes with cutting diameters from $1\frac{1}{4}$ to 3 in. and $1\frac{1}{2}$ to 6 in. The knives are renewable and adjustable. This tool is to be used on machines at a speed of 100 r.p.m. or less on fiber material and 50 r.p.m. on metal. The standard knives cut metal $\frac{1}{16}$ to $\frac{5}{16}$ in. thick. Special knives may be obtained which will cut thicknesses up to $1\frac{1}{4}$ in.

Valve, Seal Pump "Power," 1923.
Worthington Co., Inc., 115 Broadway, New York City.



This pump valve has a bottom plate which, when the valve is closed, carries the entire load and prevents the rubber seal from cutting on the seats or ribs. The bottom plate moves up and down with the rubber valve acting as a middle seat and helps to keep it in shape. The rubber acts only as a seal against leakage, all mechanical functions requiring strength and wear resistance being cared for by metal parts.

Trolley, Yale Roller Bearing Steel Plate "Power," 1923.
Yale & Towne Manufacturing Co., Stamford, Conn.



This is a flexible trolley working on an I-beam for chain blocks and motor-operated hoists. The wheels have a chilled iron tread and are mounted on roller bearings, heat-treated, hardened and ground. They are attached to the side plates which are connected together by a single equalizing pin of cold-rolled steel, which supports the shackle plate. The trolley is adjustable for larger I-beams, as the washers can be changed from outside to inside of plates and the suspension clevis can be removed and the chain hooked over the pin.

For a permanent file of new and improved power-plant equipment, clip and paste on 3 x 5-in. cards. (Patented Aug. 20, 1918.)

New Plant Construction

PROPOSED WORK

Ala., Citronelle—The City Council is in the market for ice manufacturing machinery and equipment.

Ala., Dothan—H. C. Forrester is in the market for complete ice manufacturing machinery and equipment.

Ala., Tallassee—The Alabama Interstate Power Co., B. M. Bldg., Birmingham, has been granted a 50 year license by the Federal Dam Commission and plans to build a power house, initial installed capacity 70,000 hp. (ultimate capacity 105,000 hp.); concrete dam 105 ft. high at Cherokee Bluffs on the Tallapoosa River 10 miles above here; penstocks about 800 ft. long. Noted Oct. 10, 1922.

Ark., Searcy—The Kelly Lumber Co. is in the market for power house equipment.

Calif., Glendale—The city, A. J. Van Wie, Clk., will receive bids for furnishing one 400 hp. synchronous motor.

Calif., Glendale—The Glendale Hotel Co., c/o R. F. Kitterman, 311 North Kenwood Ave., plans to build a 4 story hotel and store building on California St. Estimated cost $250,000. Engineer or architect not selected.

Calif., Los Angeles—A syndicate is having plans prepared for the construction of an 11 story, 60 x 90 ft. hotel on 6th and Columbia Sts. Estimated cost $400,000. Russell & Alspaugh, Story Bldg., Archts. Equipment detail not reported.

Calif., San Diego—St. Joseph's Hospital, c/o J. J. Cantwell, Higgins Bldg., is receiving bids for the construction of a 6 story hospital. Estimated cost $500,000. Engineer or architect not announced. Equipment detail not reported.

Calif., San Francisco—The Pacific Gas & Electric Co., 445 Sutter St., is having plans prepared for the construction of a 2 story, 42 x 80 ft. electric substation on Minna St. near 8th St. Estimated cost $40,000, not including equipment. Private plans.

Calif., San Francisco—The Pacific Telephone & Telegraph Co., 333 Grant Ave., is having preliminary plans prepared for the construction of a 20 story office building on New Montgomery St. Estimated cost $2,000,000. Private plans.

Calif., San Francisco — E. E. Young, Archt., 2002 California St., is receiving bids for the construction of a 12 story apartment house on Taylor and O'Farrell Sts. for M. A. Little, c/o Architect. Estimated cost $500,000. Equipment detail not announced. Noted June 5.

Calif., Vallejo—The San Paolo Ice Co., foot of York St., plans to build an ice plant on a 100 x 100 ft. site.

Ill., Savanna—The Carroll County Drainage & Levee Dist. 1, H. P. Greison, Secy., will receive bids until July 21 for an oil engine driven pumping plant containing a 30 in. double suction centrifugal pump, also for the construction of a pump house. Elliott & Harman Eng. Co., 144 Fredonia St., Peoria, Engrs. Former bids rejected. Noted June 12.

Kan., Marquette—The city voted $15,000 bonds for the construction of a water and light system. Engineer or architect not selected.

Kan., Salina—The city is having plans prepared and will soon call a bond election to vote on the construction of mains, pumping station and disposal plant. C. A. Haskins, 517 Finance Bldg., Kansas City, Mo., Engr.

Kan., Topeka—The Amer. Hospital Assn. is having preliminary plans prepared for the construction of a hospital on 6th St. Estimated cost $500,000. Private plans.

Kan., Wichita — W. L. Matthews, 511 First Natl. Bank Bldg., plans to build a 12 story, 100 x 140 ft. office building, including steamheating and electric power systems, also electric elevator and cooling system, on North Main St. Estimated cost $700,000. Engineer or architect not selected.

Ky., Louisville—The Knights of Columbus, 816 4th St., plans to build a 130 x 200 ft. club house, including hotel facilities, auditorium, gymnasium, etc., on 4th St. near York St. Estimated cost $600,000. Engineer or architect not selected.

Ky., Louisville—D. X. Murphy & Bro., Archts., Louisville Trust Bldg., are receiving bids and will open same about Aug. 10 for the construction of a 5 story infirmary on a 19 acre site on Eastern Parkway and Preston St. for St. Joseph's Infirmary. Estimated cost $1,500,000. Equipment detail not reported. Noted June 12.

La., Baton Rouge—S. I. Raymond, Istrouma Hotel, plans to build an 8 story hotel to contain 200 rooms. Estimated cost $500,000. Engineer or architect not announced.

Mass., Holyoke — The Holyoke Water Power Co., 1 Canal St., is having plans prepared for the construction of a 1 story, 35 x 70 ft. addition to its power plant on Riverbank St. Estimated cost $35,000. R. E. Barrett, c/o owner, Engr. and Archt. Special permission of the War Dept. has been secured to house new 7,500 steam boiler units.

Mass., Rynn — The Eastern Massachusetts Street Ry. Co., 1 Beacon St., Boston, is having plans prepared for the construction of a 50 x 100 ft., 15,000 kw., 3 phase substation, here. Estimated cost $125,000. L. H. Brown, c/o owner, Engr. Three rotary converters and control equipment will be installed.

Mich., Detroit—The First State Bank, Griswold and Lafayette Blvd., is having plans prepared for the construction of a 4 story bank building, including central steam heating equipment and elevators. Estimated cost $500,000. A. Kahn, 1000 Marquette Bldg., Detroit, Archt.

Mich., Northville—The Wayne County Bd. of Supervisors, W. H. Maybury, Chn. Bldg. Co., 635 West Ferry St., Detroit, is having plans prepared for the construction of a 1 story training school, including fourteen cottages, administration building and central kitchen with central steam heating plant, on the Northville-Plymouth Rd., here. Estimated cost $500,000. M. R. Burrowes, 2631 Woodward Ave., Detroit, Archt.

Minn., Houston—The Houston County Drainage & Conservancy Dist. 1 is having preliminary plans prepared for the construction of levees; ditches; pumping station, 80,000 g.p.m. capacity against 18 ft. head; 250 hp. motor or oil engine. Estimated cost $428,000. Central States Eng. Co., 602 Laurel Bldg., Muscatine, Ia., Engrs.

Miss., Columbus—The State Geological Dept. will have a survey made of the Tombigbee River for water power development. E. L. Kudenall, Pres. Chamber of Commerce, Columbus, interested.

Mo., Kansas City—The Heart of America Hospital, c/o J. O. Hogg, Archt., 22nd and Oak Sts., is having plans prepared for the construction of a 12 story, 190 x 230 ft. hospital on 31st and Tracy Sts. Estimated cost $2,000,000. W. E. Gilham, 409 Interstate Bldg., Kansas City, Engr. Equipment detail not reported. Noted May 15.

Mo., Piedmont—The city defeated $40,000 bond issue for the construction of a waterworks system. A new election will probably be called. E. A. Fuller, 1917 Railway Exch., St. Louis, Engr. Noted May 8.

N. J., Glen Rock (Ridgewood P. O.)—The village will receive bids about Aug. 25 for extensions to sewerage system and construction of a small pumping station. Estimated cost $52,000. H. J. Harder, 129 Market St., Paterson, Engr.

N. J., Trenton—The State Bd. Educ. received bids for engine and generator from the Ridgway Dynamo & Engine Co., Ridgway, Pa., $10,940; electrical work from Carr & Schultz, Perry and Stockton Sts., Trenton, $3,816; refrigerator from Brunswick-Kroschele, New Brunswick, $6,400. Noted June 26.

N. Y., New York—The Knights of Columbus, 244 East 51st St., are having plans prepared for the construction of a 12 story, 100 x 150 ft. building on 8th Ave. and 51st St. Estimated cost $1,650,000. E. F. Fanning, 522 5th Ave., New York, Engr. and Archt. Equipment detail not reported.

N. Y., Syracuse—The Syracuse Intercepting Sewer Bd., H. J. Mamlin, Secy., 104 City Hall, will receive bids until July 19 for an intercepting sewer as follows: (contract 37) four settling tanks, 71 ft. square and 12 ft. deep; two 18 x 26 ft. pumping stations and miscellaneous appurtenances, including c.i. pipe, sluice gates, 24 x 48 Venturi meter; (contract 38) electric lighting for above structures; (contract 39) cleaning mechanisms for four settling tanks.

N. C., Bakersville—The Bakersville Roller Mills are in the market for ice manufacturing machinery and equipment.

N. C., Raleigh—The State Hospital for Insane, A. A. Anderson, Supt., has had plans prepared and will soon receive bids for the construction of central heating plant, connecting mains and heating work in buildings for the Colony Group; underground electric distributing system for light and power for the Institution. Wiley & Wilson, 907-10 Peoples Natl. Bank Bldg., Lynchburg, Va., Engrs.

Ohio, Akron—The Akron Savings & Loan Co., c/o A. Hopkins, Archt., 101 Park Ave., will soon award the contract for the construction of a 12 story bank and office building on South Main St. Estimated cost $600,000. Equipment detail not reported. Noted Apr. 24.

Ohio, Cincinnati—The Bd. Educ., 511 West Court St., received bids for heating and ventilating systems in Hartwell Public School from the Sodermann Heat & Power Co., 2306 Morgan St., St. Louis, Mo., $43,447; in addition to Hughes High School from the Williamson Heater Co., 335 West 5th St., Cincinnati, $36,190. Noted June 19.

Ohio, Cleveland—The city, Dept. of Purchases, City Hall, is in the market for two underfeed 1,400 hp. mechanical stokers for two Connolly boilers.

Ohio, Columbus—The Henderson Tire & Rubber Co., Goodall Blvd. along tracks of Hocking Valley Ry., W. O. Henderson, Pres., is in the market for electric motors, etc.

Ohio, Shaker Heights (Cleveland P. O.)—The University School, c/o A. C. Brown, 4403 St. Clair Ave., Cleveland, is having plans prepared for the construction of a group of 2 and 4 story school buildings, including steam heating plant, on North Woodland St., here. Estimated cost $1,000,000. Walker & Weeks, 1900 Euclid Ave., Cleveland, Archts. Noted May 1.

Ore., Wallowa — The Bowman Hicks Lumber Co. is having plans prepared for the construction of a saw and planing mill; railroad yards; station; electric light and power plant; sewer and water works; hotel, store, warehouse, theatre, etc., on a town site about 16 miles south of here. Estimated cost $500,000. C. B. Miller, La Grande, Archt. The architect is in the market for electric light and power machinery, waterworks material, etc.

Pa., Pittsburgh — The Allegheny County Comrs., Court House, received bids for the construction of a 1 story, 110 x 190 ft. fan house on 2nd and Ruth Sts. from Williams & Haas, Empire Bldg., Pittsburgh, $193,859, alternate $181,222; Rose & Fisher, Pennsylvania Ave., Pittsburgh, $196,707, $184,700; Rust Eng. Co., Ross St., Pittsburgh, $221,420, $211,500; also for electric power and lighting equipment for Liberty Tunnel from Booth & Flynn, 1942 Forbes St., Pittsburgh, $168,000; Electric Service Co., 212 Walnut St., Cincinnati, Ohio, $168,900; Craig Electric Co., 418 6th Ave., Pittsburgh, $182,070.

Pa., Rural Valley—The Rural Valley Boro Electric Corp., c/o G. E. Murrie, plans to build an electric light and power plant and is in the market for machinery, equipment and boilers.

Pa., Sharon—The Sharon Coal & Supply Co., 305 South Dock St., is in the market for coal handling machinery and equipment.

Pa., Warren—C. Zerres is in the market for ice plant, also handling machinery and equipment.

Tenn., Memphis—The Sisters of St. Francis are having plans prepared for the construction of a 3 story, 50 x 210 ft. hospital on Summer Ave. Estimated cost $300,000. H. J. Kramer, 632 Goodwyn Institute, Memphis, Archt. Equipment detail not reported.

Tex., Dallas—R. H. Baldridge, 528 Interurban Bldg., is in the market for a 100 cu.ft. air compressor and engine.

Tex., Dallas—J. P. Burrus, Interurban Bldg., F. Wozencraft, Wilson Bldg., C. L. Sanger, c/o Sanger Bros., Elm, Main, Lamar and Austin Sts., et al., are having plans prepared for the construction of a 6 story Fine Arts building, including auditorium, stores, studios, etc., on Congress, Jackson and Poydras Sts. Estimated cost $750,000. R. H. Hunt & Co., Great Southern Life Bldg., Dallas, Archts. Equipment detail not reported.

Tex., Dallas—The B. E. Keith Co., Cadiz and Preston Sts., plans to build a 3 story, 90 x 135 ft. produce and fruit storage building, including refrigerating and ventilating systems. Cost between $175,000 and $200,000. Engineer or architect not announced.

Tex., Dallas—The Shop, P. O. Box 893 (machine shop), is in the market for one double drum, 20 hp., and one 3 drum, 35-40 hp. engine.

Tex., Denison—The Denison Hotel Co., c/o J. M. Crumpton and A. O. Simpson, has had plans prepared and will soon receive bids for the construction of a 6 story, 110 x 120 ft. and 48 x 110 ft. hotel. Estimated cost $250,000. W. J. Knight & Co., Wainwright Bldg., St. Louis, Mo., Engrs. Barnett, Haynes & Barnett, Century Bldg., St. Louis, Mo., Archts. Equipment detail not reported. Noted June 12.

Tex., Fort Worth—The Methodist Conference, c/o W. E. Williams, Texas State Bank, is having plans prepared for the construction of a 10 story sanitarium. Estimated cost $1,000,000. W. G. Clarkson, First Natl. Bank Bldg., Forth Worth, Engr. and Archt. Equipment detail not reported. Noted Sept. 26, 1922.

Tex., Grand Prairie—The City, G. H. Turner, Mayor, is having plans prepared for waterworks improvements, including 300 ft. well, oil engine driven compressor for air lift and water main extensions. Estimated cost $4,000. Koch & Fowler, 606 Central Bank Bldg., Dallas, Engrs.

Tex., Galveston—J. St. Mary, 2205½ B St., is having sketches prepared for the construction of a 12 story hotel on R and 26th Sts. Estimated cost $250,000. P. G. Siber & Co., Bedell Bldg., San Antonio, Engrs. and Archts.

Tex., Paducah—The city plans the construction of a waterworks system, water supply from wells, pumps, etc. A test well is being drilled. Estimated cost $75,000. Engineer or architect not announced.

Tex., San Antonio—The Daly-Moffatt Hotels, Inc., Houston, plans to build a 3 story, 140 x 160 ft. hotel, here. Estimated cost $500,000. Engineer or architect not selected.

Va., Yorktown—The Bureau of Yards & Docks, Navy Dept., received bids for power plant equipment and piping at the Navy Mine Depot, here, from Noland Clifford Co., 330 28th St., Newport News, $15,265; Newport Ctg. & Eng. Co., Law Bldg., Newport News, $17,658; W. G. Cornell Co., 19 Patterson St., N. E., Wash., D. C., $18,985. Noted June 5.

W. Va., Fairmont—The B.P.O.E. is having preliminary plans prepared for the construction of a 4 story, 80 x 160 ft. club building on Adams St. Estimated cost $250,000. J. C. Burchinal, Fairmont, Archt. The owner will purchase electric elevators, refrigerating machine, vacuum vapor heating and mechanical ventilation systems.

W. Va., Weston—The Monongahela-West Penn Public Service Co. is in the market for machinery and equipment for power plants at Sutton, Parsons and Elkins.

Wis., Cuba—The Connecting Link Mining Co., C. M. Treat, Secy., is having plans prepared for the construction of a 1 story, 60 x 90 ft. mining wet cell mill. Estimated cost $40,000. Private plans. The owner is in the market for power machinery and hoists.

Wis., Fond du Lac—J. E. Hennen, Engr., 74 South Main St., is receiving bids for a steam heating plant, including boiler, for store building for F. Skaff, 111 South Main St.

Wis., Madison—The State Bd. of Control, Capitol Bldg., F. Crocker, Secy., is in the market for ammonia refrigeration plant, ice machine, etc., for refectory at Union Grove.

Wis., Milwaukee—The city received bids for the construction of a gate house and distribution system at Riverside pumping station from P. Riesen's Sons, 1018 Humboldt Ave., $64,777; two 100 kw. uniflo engines and generators from Ames Iron Wks., 25 East 2nd St., Oswego, N. Y., $16,250 and $16,850. Noted June 12.

Wis., Milwaukee—The Elks' Bldg. Com., 208 City Bank Bldg., and R. Messmer & Bro., Archts., 221 Grand Ave., are receiving bids for the construction of an 8 story, 110 x 145 ft. temple on Mason and Marshall Sts. Estimated cost $1,000,000. Equipment detail not reported. Noted May 15.

Wis., Milwaukee—The Hotel Wisconsin, 172 3rd St., and Holabird & Roche, Archts., 104 South Michigan Ave., Chicago, will soon receive bids for the construction of a 12 and 15 story, 50 x 150 ft. addition to hotel. Estimated cost $1,000,000. Equipment detail not reported. Noted Jan. 30.

Wis., Port Washington — The city, c/o Clerk, is having plans prepared for the construction of a central heating plant and system. Estimated cost $125,000. E. E. Dillon, Washington Bldg., Madison, Engr. Noted Mar. 27.

Wis., Sheboygan—W. C. Weeks, Engr., 720 Ontario St., is receiving bids for a steam heating plant and two pressure boilers in store building for the Sells Real Estate Co., 901 North 8th St. Estimated cost $25,000.

Wis., Wauwatosa—C. Lutzen, 227 Harvey Ave., is in the market for electric motors.

Man., St. Boniface—The Dominion Tar & Chemical Co., Ltd., L. O. P. Walsh, Vice Pres., is in the market for complete equipment for boiler house and distillery, also three storage tanks.

Man., Winnipeg—The Winnipeg Hydro Co., J. G. Glassco, 2 Evergreen Pl., Mgr., is in the market for superheaters for boiler and a de-aerating open heater. Estimated cost $20,000 and $10,000 respectively.

Ont., North Bay — The Hydro-Electric Co. is in the market for three steam generators to replace fire loss at substation on Harriet St., Gormonville.

Ont., North Bay — The Hydro-Electric Power Comn., 190 University Ave., Toronto, is having plans prepared for additional power development on Nipissing system, here, including two new 450 kva. units, about 1,200 hp. total on Bingham Chutes; increase of Nipissing power development, by addition of 1,200 hp. unit and pipe line. F. A. Gaby, Ch. Engr. It is also proposed to install 4,000 hp. at Cox's Chutes and 1,000 hp. at Elliott's Chutes, both on South River, and 600 hp. Diesel oil engine reserve for low water conditions, here.

Every one of these items is reported by our authorized correspondents who are instructed to verify every item sent in. This free weekly service is published in the interests of the buyer and the seller, to bring them together and get machinery moving.

Everything possible is done to insure authenticity and timeliness.

Your co-operation is invited in helping us maintain this service at the highest efficiency.

BUSINESS NEWS DEPARTMENT
Tenth Ave. at 36th St., New York

Que., Montreal—The Bleury-Concord Co., Ltd., c/o A. L. Caron, 168 St. Catherine Rd., Outremont, plans to build a 10 story, 112 x 136 ft. office and manufacturing building on Bleury St., here. Estimated cost $700,000. Engineer or architect not selected.

Que., Montreal — Ross & McDonald, Archts., Belmont St., are preparing plans for the construction of the 10 story New Keefer Bldg. on Catherine and McKay Sts. Estimated cost $2,000,000. Equipment detail not reported.

CONTRACTS AWARDED

Calif., Los Angeles—W. M. Garland, 749 South Spring St., awarded the contract for the construction of a 12 story office building on Main and 9th Sts. to P. J. Walker, Merchants Natl. Bank Bldg., Los Angeles. Equipment detail not reported. Noted Mar. 6.

Calif., Los Angeles — The San Jacinto Dwellings Co., c/o Russell & Alpaugh, Archts., Story Bldg., awarded the contract for the construction of a 13 story apartment house with separate garage building on 6th and Carondelet Sts. to the Richardson Bldg. & Eng. Co., 141 Larchmont Blvd. Estimated cost $700,000. Equipment detail not reported.

Ill., Quincy—The Quincy Gas, Electric & Heating Co., 422 Main St., awarded the contract for the construction of a 60 x 75 ft. retort house, eighteen horizontal coke ovens, conveyors, etc., with capacity for carbonizing 75 ton of coal per day, to the Russell Eng. Co., Railway Exch. Bldg., St. Louis, Mo. Estimated cost $200,000.

Mass., Holyoke—The Farr Alpaca Co. awarded the contract for the construction of a 2 story, 63 x 73 ft. boiler house and a 63 x 73 ft. steam turbine plant on Jackson St. to the D. O'Connell's Sons Co., 480 Hampden St., Holyoke. Estimated cost $150,000. The S. M. Green Co., Engrs., 293 Bridge St., Springfield, will purchase all equipment.

Mass., Springfield—The United Electric Light Co., State St., awarded the contract for the construction of a 1 story, 30 x 60 ft. power house on Page Blvd. to L. S. Wood, 14 Stockbridge St., Springfield. Estimated cost $36,000.

Minn., Minneapolis—H. S. Goldie, 910 Newton Ave., representing owners, awarded the contract for the construction of a 6 story, 120 x 250 ft. apartment hotel on West Lake St. and Dean Blvd. to the Standard Home Bldg. Co., Andrus Bldg., Minneapolis. Estimated cost $1,300,000. Steam heating system will be installed.

Minn., St. Cloud—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., awarded the contract for heating, plumbing and boiler house equipment for hospital, here, to H. Kelly & Co., 925 Plymouth Bldg., Minneapolis, $197,851; electric work to Strang Electric Co., 214 South 7th St., Phila., Pa., $30,233; refrigerating equipment to Milwaukee Steam Appliance Co., 709 63rd Ave., West Allis, Wis., $7,990. Noted June 5.

Mo., St. Louis—The St. Louis-San Francisco R.R., 900 Olive St., awarded the contract for the construction of a 1 story repair shop, 20 stall roundhouse, power house, machine shop, mill shop, store room, etc., on Fyler Ave., to T. S. Leake & Co., 608 South Dearborn St., Chicago. Estimated cost $500,000. Noted June 5.

Ohio, Orient—The Dept. of Welfare, 9th and Oak Sts., Columbus, J. E. Harper, Dir., awarded the contract for the construction of a 48 x 115 ft. cold storage plant, etc., at the Institute for Feeble Minded, here, to D. W. McGrath & Sons, 255 East Broad St., Columbus. Estimated cost $29,000. Noted June 12.

Pa., Pittsburgh — The Allegheny County Steam Heating Co., 703 Chamber of Commerce Bldg., awarded the contract for the construction of a 6 story, 62 x 68 ft. central steam heating plant, including underground mains, on Duquesne Way, to the Dwight P. Robinson Co., Inc., 125 East 46th St., New York. Estimated cost $1,000,000.

S. C., Greenville—The Southern Worsted Corp. awarded the contract for the construction of a 1 story, 180 x 578 ft. woolen mill, boiler house, water tank, small dam and pump house to the Gaston Constr. Co., Gastonia, N. C. Estimated cost $150,000. Noted June 19.

Wash., Everett — The Providence Hospital Assn. awarded the contract for the construction of a 4 story hospital to A. W. Quist & Co., Hoge Bldg., Seattle. Estimated cost $300,000. Equipment detail not reported.

Wash., Seattle—The United Hotels Co., 25 West 45th St., New York, awarded the contract for the construction of a hotel here, to Grant, Smith & Co., Henry Bldg., Seattle. Estimated cost $3,000,000. Equipment detail not reported. Noted Oct. 31, 1922.

Wis., Merrill—G. B. Cotter, 1110 3rd St., will build a 1 story, 38 x 108 ft. excelsior factory. Estimated cost $40,000. The owner is in the market for conveying machinery, Corliss engine, steam pumps, 185 hp. tubular boiler, etc.

Wis., Shorewood (Milwaukee P. O.)—The village awarded the contract for installation of an electric lighting system to the Herman Andrae Electric Co., East Water St., Milwaukee, $38,800; furnishing insulated wire, Kerite Insulated Wire & Cable Co., 122 South Michigan Ave., Chicago, $13,499; concrete parts and transformer vaults to the Massey Concrete Products Co., Port Washington Rd., Milwaukee, $12,705; transformers to the Kuhlman Electric Co., 26th and Jefferson Sts., Bay City, Mich., $6,047. Noted Feb. 20.

T. H., Pearl Harbor—The Bureau of Yards & Docks, Navy Dept., Wash., D. C. awarded the contract for refrigerating equipment for the Marine Reservation here, to the Frick Co., Inc., Waynesboro Pa., $3,150. Noted June 5.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

Declines—White and red lead, dry and in oil, dropped ½c. per lb., f.o.b. New York, effective July 2. Raw linseed oil (5-bbl. lots) quoted at $1.13 per gal., f.o.b. New York, against $1.16; at $1.27, down from $1.33 in Cleveland and $1.28, compared with $1.37, one month ago, in Chicago. Minimum on steel rivets down 25c. per 100 lb. at Pittsburg mill. Babbitt metal, all grades, cheaper in New York, Cleveland and Chicago. Slight downward tendency in chrome and silica brick at eastern shipping points. In electrical supplies, armored-cable and rubber-covered copper wire show substantial declines during month.

Advances—None reported in power-plant and electrical supplies since June 12.

POWER-PLANT SUPPLIES

HOSE—

Fire	50-Ft. Lengths
Underwriters' 2½-in., coupled	58c. per ft.
Common, 2½-in., 3-ply	$1.00 per ft. list less 40–5%

Air	First Grade	Second Grade
¼-in., per ft.	3-ply $0.35½	4 ply $0.26½

Steam—Discounts from List

First grade	40%	Second grade	40–5%
Third grade	40–10%		

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition	60%	Best grade	50–10%

LEATHER BELTING—List price per ply, 12-in. wide, per lin ft. $2.88

Grade	Discount from list
Medium	30–10%
Heavy	20–5–2½%

RAWHIDE LACING { For cut, best grade, 40%, 2nd grade, 50%. For laces in sides, best, 48c. per sq.ft.; 2nd, 43c. Semi-tanned: cut, 40%; sides, 48c. per sq.ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam, ⅛ in.	$0.90
Asbestos for high-pressure steam, ⅛ in.	1.70
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.80
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.30
Asbestos wick, ½- and 1-lb. balls	50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		45%
For low-pressure heating and return lines	4-ply	70%
	3-ply	72½%
	2-ply	75%

PORTLAND CEMENT—New York, $2.70@ $2.80 per bbl. without bags, in cargo lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.64 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York Current	Cleveland	Chicago
White	10.00@13.00	15.00	11.25
Colored	8.00@13.00	12.00	8.00

WIPING CLOTHS—Jobbers' prices, in cents per lb., as follows:

	13¼ x 13¼	13¼ x 20½
Chicago	10.00	13.00
New York	10.75@11.00	.....
Cleveland	$36.00 per M.	$52.00 per M

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$1.13	$1.27	$1.28

WHITE AND RED LEAD—Base price in cents per pound:

	Red				White	
	Current		1 Year Ago		Current	1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry or In Oil	Dry or In Oil
100-lb. keg	14.00	15.50	12.50	14.00	14.00	12.50
25- and 50-lb. keg	14.25	15.75	12.75	14.25	14.25	12.75
12½-lb. keg	14.50	16.00	13.00	14.50	14.50	13.00
5-lb. cans	17.00	18.50	15.50	17.00	17.00	15.50
1-lb. cans	19.00	20.50	17.50	19.00	19.00	17.50

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅛ and smaller	40%	50–10%	60%
Tinned	40%	50–10%	4½c. per lb. net

Structural rivets, ½, ⅝, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.

New York	$4.40	Chicago	$3.75	Pittsburgh	$3.25

Boiler rivets, same sizes:

New York	$4.50	Chicago	$3.85	Pittsburgh	$3.35

REFRACTORIES—Prices in car lots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$50@55
Chrome cement, 40@50% Cr_2O_3, in bulk	net ton	27@32
Chrome cement, 40@50% Cr_2O_3, in sack	net ton	31@36
Magnesite brick: 9-in. straights	net ton	65@68
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50@74.80
Magnesite brick: Soaps and spits	per ton	92.00@96.20
Silica brick: Mt. Union, Pa.	per M	45.00@46.50
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	48@55
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	45@47
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	45@47
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	43@50
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	40@43
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	42@45
Chrome ore crude, 40@50%	net ton	20.00@25.50

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
(83% tin)	56.00	51.00	40.00
(35% tin)	30.00	17.50	16.00

COLD FINISHED STEEL—Warehouse prices are as follows:

	New York	Cleveland	Chicago
Round shafting and screw stock, per 100 lb. base	$4.40	$3.90	$4.30
Flats, square and hexagons, per 100 lb. base	4.90	4.40	4.80

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	60-10%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the latest Pittsburgh basing card:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	62	50½	¼ to 1½	30	13

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½ to 4	26	11
7 and 8	56	43½	4½ to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	¾ to 1½	30	14
2 and 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.23
1¼	.....	.....	.25
1½	.....	.....	.22
1¾	$0.26	$0.29	.23
2	.20	.25	.21
2¼	.23	.29	.23
2½	.24	.33	.28
2¾	.....	.....	.....
3	.30	.41	.32
3¼	.32	.47	.35
3½	.34	.51	.37
4	.43	.64	.47

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special engths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2¼ in. diameter, 7c. per cut
2½ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3¼ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 49.00 (net)	$ 84.00 (net)	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

		Lead Covered
Less than coil lots	25%	10%
Coils to 1,000 ft.	30%	20–5%
1,000 to 5,000 ft.	35%	25%
5,000 ft. and over	40%	30%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
¼	$61.10	$66.16	$9.90	$11.03	$5.74	$6.16
⅜	79.20	84.95	13.00	14.49	8.18	8.78
1	112.06	122.19	19.26	21.46	10.65	11.42
1¼	151.62	165.31	25.65	28.33	14.76	15.78
1½	181.28	197.67	34.19	37.77	18.23	19.47
2	248.90	265.94	62.70	69.24	24.29	25.97
2½	385.50	420.48	102.58	11.33	34.71	37.10
3	504.29	548.81	273.40	302.12	51.66	55.63
3½	633.86	688.65	604.03	667.15	69.41	74.19
4	772.62	838.59	697.06	770.99	86.76	92.73

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.10	D. P. D. B.	$0.32
D. P. M. L.	.16	T. P. S. B.	.30
T. P. M. L.	.24	T. P. D. B.	.42
D. P. S. B.	.18		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.39	$1.00	$2.10
T. P. M. L.	.60	1.47	2.80
D. P. S. B.	.49	1.26	.....
T. P. S. B.	.92	2.10	.....
D. P. D. B.	.89	2.46	.....
T. P. D. B.	1.57	4.20	.....
T. P. to D. P. D. B.	1.05	2.88	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy	$23.00
No. 16 cotton reinforced heavy	29.00
No. 18 cotton reinforced light	19.50
No. 16 cotton reinforced light	22.50
No. 18 cotton Canvasite cord	17.00
No. 16 cotton Canvasite cord	19.25

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.20	3-amp. to 30-amp.	100	$0.40
35-amp. to 60-amp.	100	.30	35-amp. to 60-amp.	100	.60
61-amp. to 100-amp.	50	.90	65-amp. to 100-amp.	50	1.50
101-amp. to 200-amp.	25	2.00	110-amp. to 200-amp.	25	2.50
201-amp. to 400-amp.	25	3.60	225-amp. to 400-amp.	25	5.50
401-amp. to 600-amp.	10	5.50	450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package, 55%; 1-5th to standard package, 60%; standard package, 65%.

RENEWABLE FUSES, ENCLOSED—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0–30 ampere, standard package (500)	$2.70
0–30 ampere, less than standard package	3.00

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs or Bowl Enameled Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.32	$0.37	120	75	$0.55	$0.60	60
15	.32	.37	120	100	.70	.75	24
25	.32	.37	120	150	.90	.95	24
40	.32	.37	120	200	1.15	1.25	24
50	.32	.37	120	300	1.75	1.85	24
60	.37	.42	120				
				500	2.50	2.65	12
				750	3.75	4.00	8
				1,000	4.25	4.50	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.19
Composition 2-piece attachment plug	.29
Swivel attachment plug	.12

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 7.60	$ 9.90	$11.60	$18.33
12	9.95	12.60	14.26	23.83
10	13.25	16.40	18.32	30.63
8	18.50	21.00	23.52	41.27
6	.....	.....	34.10	.....
4	.....	.....	46.80	.....
2	.....	.....	67.56	.....
1	.....	.....	87.65	.....
0	.....	.....	116.09	.....
00	.....	.....	137.63	.....
000	.....	.....	164.68	.....
0000	.....	.....	201.44	.....

SOCKETS, BRASS SHELL—

¼ In. or Pendant Cap Key Each	¼ In. or Pendant Cap Keyless Each	¼ In. or Pendant Cap Pull Each	⅜ In. Cap Key Each	⅜ In. Cap Keyless Each	⅜ In. Cap Pull Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package	20%
1-5th to standard package	25%
Standard package	35%

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb.
Rubber tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb.
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	29c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c. or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	25%
$25 to $50 list value	30%
$50 list value or over	35%